SUSTAINABLE SUBURBIA

A New Development Model for Fallow Suburban Residential Sites

University of Hawai'i at Manoa
School of Architecture

Mark Di Cecco

Submitted towards the fulfillment of the requirements for the
Doctor of Architecture degree
December 2009

Doctorate Project Committee:
Clark Llewellyn, Chairperson
Gordon Grau
Matthew Winegar

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We certify that we have read this Doctorate Project and that, in our opinion, it is satisfactory in scope and quality in fulfillment as a Doctorate of Architecture Project for the degree of Doctor of Architecture in the School of Architecture, University of Hawai'i at Manoa

Clark Llewellyn, Chairperson

Gordon Grau

Matthew Winegar

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For Kim

Before modern man can gain control over the forces that now threaten his very existence, he must resume possession of himself. This sets the chief mission of the city of the future: that of creating a visible regional and civic structure, designed to make man at home with his deeper self and his larger world...

Lewis Mumford

agricultural artist Matthew Moore did "Rotations: Moore Estates" on his family's farm in Phoenix Arizona after their sale of a parcel of land for home development

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My Doctoral Committee: Chairman and Dean of the School of Architecture Clark Llewellyn AIA, for academic as well as professional encouragement when needed, criticism when warranted, and buttkicking when necessary. Dr. Gordon Grau for the reminder and realization that all we do as a society is intertwined with nature, all that is local is necessarily regional, and all of our sins as humans ultimately flow to the ocean. Matthew Winegar, AICP who added a unique combination of vision for the future of the built environment and the reality of getting things done from a city perspective as well as from the development realm.

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And finally to Marvin Malecha FAIA and Dr. Homer Williams FAIA for planting the seeds that made this journey back to school possible in the first place.

SUBURBAN GLOSSARY

NIMBY	Not in my backyard
NIMFYE	Not in my front yard either
NIMTOO	Not in my term of office
NIMEY	Not in my election year
NIMBL	Not in my bottom line
NIABY	Not in anyone's backyard
NOTE	Not over there either
NOOSE	Not on our streets either
NOPE	Not on planet earth
BANANA	Build absolutely nothing anywhere near anything
CAVE	Citizens against virtually everything
CRAVE	Citizens radically against virtually everything
LULU	Locally undesirable land use
SLAPP	Strategic lawsuit against public participation
DEAD	Decide, educate, announce, defend
TOADS	Temporarily obsolete abandoned derelict sites
LUST	Leaking underground storage tank
GOMBY	Get out of my backyard
DUDE	Developer under delusion of entitlement
ALARA	As low as reasonably achievable (density)
APE	Area of potential effect
FOE	Friends of the earth
PETS	Proposed, endangered, threatened species
FONSI	Findings of no significant impact
PIITBY	Put it in their back yard
RUID	Review it until it dies
YIMBY	Yes in my backyard (for a price)

ABSTRACT

fallow: (of farmland) plowed but left unsown in order to restore its fertility or to avoid surplus production.

The recent economic crisis has put suburban single family residential community building at a standstill. This has left unfinished projects across the country. Many of these projects are entitled sites, with infrastructure, utilities, roads and graded lots in place or in various states of completion. These residential lots without houses lie fallow while the developers of these sites often are no longer involved with the projects, typically leaving the lots with a financial institution incapable of maintaining them in the short term. There is now an opportunity to encourage sustainable development within these very locations. This project will take a typical block of low-density single-family homes within a typical site and replace it with a higher-density, net-zero-source-energy, sustainable multi-use neighborhood within the same space.

The typical approved suburban development has standardized land use, individual site sizes, and road locations and widths. As part of its approval, the development had to account for supplying the site with water, sewer, storm drain, electricity and gas utilities. Using an individual home as a benchmark, the research will look at house and lot size in relation to demographics and use patterns, determine the demand for land and utilities, and then develop an alternative solution that decreases the load on these existing utilities while increasing the density of residential units within the site. These findings will be combined with placemaking town planning ideals. The advent of the new Green Economy requires places for new companies to innovate and create the products and services of the future. Provisions for business incubator type flexible multi-use opportunities within the block will provide these places. The goal will be to create an integrated

sustainable model block to replace the current suburban standard, and provide options for how to take this block and increase its scale to a larger multi-block community.

As the economy recovers, developers will repurchase these currently distressed properties and begin to build on them. There is a need to provide them with a sustainable alternative to the current suburban model. The research will demonstrate that there is an opportunity to increase on-site unit count without the costs associated with upgrading or replacing the existing infrastructure to do so, or increasing the need for additional utilities and services to the site. This rationale would apply to the developer proposing this change to the jurisdiction that approved the original project, and has the ability to provide an opportunity for the jurisdiction to meet its affordable housing goals. Creating a neighborhood as opposed to creating a block of houses would make the project more approvable and attractive to buyers.

The public needs to understand that the single family suburban subdivision is not environmentally sustainable, that it is possible to live more sustainably while living in a more compact community that contains more than houses, with opportunities to walk or bike to work, services, and greenspace. They need to have a choice in how to live as well as where to live, and they have a responsibility to their children and the planet to live within our environmental means. With this understanding, as they chose to live this way, developers will tailor their development practices to meet this new market demand. It is hoped that eventually there will be no more of these fallow projects, people are living in real sustainable communities, and we can lead by example in a new way of living and how we develop communities.

Prologue

"Private regulation generally has proved far better at constraining excessive risk-taking than has government regulation."
Alan Greenspan in 2005.

"I guess I should warn you, if I turn out to be particularly clear, you've probably misunderstood what I've said."
Alan Greenspan in 2007.

What was supposed to happen here.

The landowner, tired of fighting to keep farming while food prices decline and his neighbors in the new suburb complain about tractor noise and dust, accepted a fair price for his land. The developer, anxious to make the highest and best use of the land and their investment, worked with the city and accepted their fees and conditions to provide the new neighborhood with utilities, police and fire services. They met with the public, held workshops, donated to local charities, and included amenities the public wanted. The

Figure 1.1.
image © Alex Mac Lean

city balanced the demands of the public, their mandated affordable housing requirements, and their concerns for the environment with the best planning efforts their development code would allow. The public, many who had escaped older first-ring suburbs recently to raise their children in a newer community, negotiated with the developer to protect their lifestyle and the environment. Some looked forward to the day they could move up into this new guard-gated executive neighborhood with its big houses, broad curving streets and plenty of elbow room.

While all of this occurred, changes in global investment markets occurred that would threaten the entire process.

The collective pool of investment capital (from corporations, countries, institutions and private investors) globally is for the most part tied up in what are known as fixed income securities.[1] Prior to the year 2000, that pool had grown slowly to about 36 trillion dollars. After 2000, the global pool of fixed income securities doubled in size to 70 trillion dollars, mainly from developing countries such as India, China and the Middle East trading with the United States. Prior to 2000, these funds were typically invested in safe investments such as treasury and municipal bonds. With the rapid doubling of this pool of funds, there were not enough of these safe investments available. At the same time, the United States Treasury decided to keep interest rates low, making safe, conservative U.S. treasury bonds unattractive investments.[2]

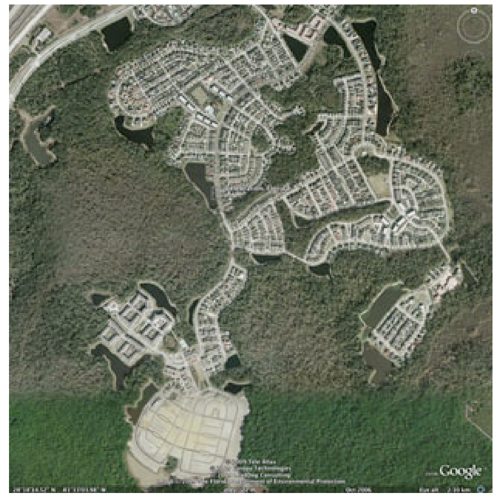


Figure 1.2.
unbuilt lots in Celebration, Florida

The pool of money was then attracted to United States residential mortgage-backed securities that had significantly higher rates of return for their investment. A group of individual home mortgages are packaged together, and then shares of the monthly income (as each mortgage holder makes their mortgage payment) from the package are sold as mortgaged backed securities. The thought was that the United States housing market was always going to give a positive return on the investment. As the pool's appetite for these types of securities grew, banks began to change the way mortgages worked to increase the supply of mortgages available for these

Figure 1.3.
unbuilt lots in Newcastle, Delaware

1. Alex Blumberg, "The Giant Pool of Money," in This American Life, ed. Ira Glass (2008).

2. Chris Isadore, "Greenspan: More Cuts Possible," http://money.cnn.com/2003/07/15/news/economy/greenspan/.

securities. They changed the types of loans available, and reduced the requirements to obtain a mortgage. So over a short period of time, a standard thirty year mortgage at a fixed rate with a twenty percent down payment and proof of good credit requirements for the mortgage holder morphed into a thirty year, adjustable no down payment NINA (no income, no asset proof required) loan.[3]

Figure 1.4.
unbuilt lots in Moorpark, California

Based on these new types of mortgages, a flood of new buyers who could previously not qualify to purchase a home appeared. This increased the demand for new housing subsequently inflating the home prices. Some of these new home buyers had no job or credit, many through these new loan vehicles had no investment into the process, but they were told they could buy a $500,000 house. The standard comment about the ability to get mortgages for these people was, "if you could fog a mirror with your breath, they'll make you a loan."[4] The mortgage brokers and investment banks were in direct competition with each other to provide these loan vehicles to feed the demand of the investors. No one (the bankers, the brokers, nor the people taking out these mortgages) worried that these loans were no good. People that actually afford the house that they lived in suddenly saw that they could, with these new types of mortgages, get a much bigger house. Many of them did, and others refinanced to these new types of loans to pull out home equity that was then used to purchase items like cars.[5] Developers saw only that these buyers had qualified for a loan, and built houses as quickly as they could to meet the demand, and moved

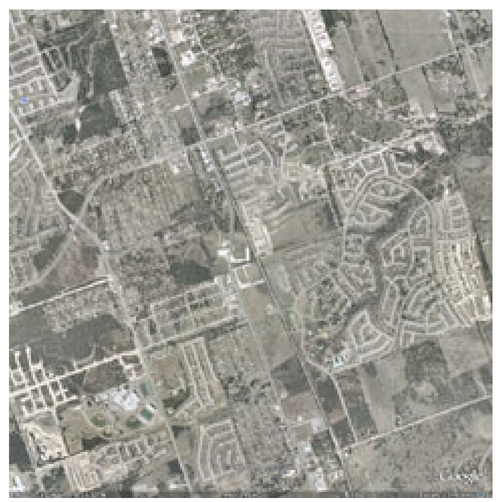


Figure 1.5.
unbuilt lots in Cedar Park, Texas

3. David Reed, "Loan Fraud: Just Don't Do It," Realty Times, February 13 2004.
4. Jon Birger, "They Call Them Flippers," http://money.cnn.com/2005/03/14/magazine/flippers_0504/index.htm.
5. National Association of Realtors, "Housing: An Investment and a Piggybank for Spending," (2003).

from building "starter homes" to larger, more elaborate ones. As the real estate market heated up, many people saw that they could make money in selling houses. They took out loans on their existing houses to buy "flipper"[6] homes. These homes were purchased with little money down, the house was then fixed up, and put back on the market quickly, in hopes of making quick money. Others chose the route of quickly getting their real estate license to allow them to buy and sell homes.[7] This provided even more mortgages for the securities investors.

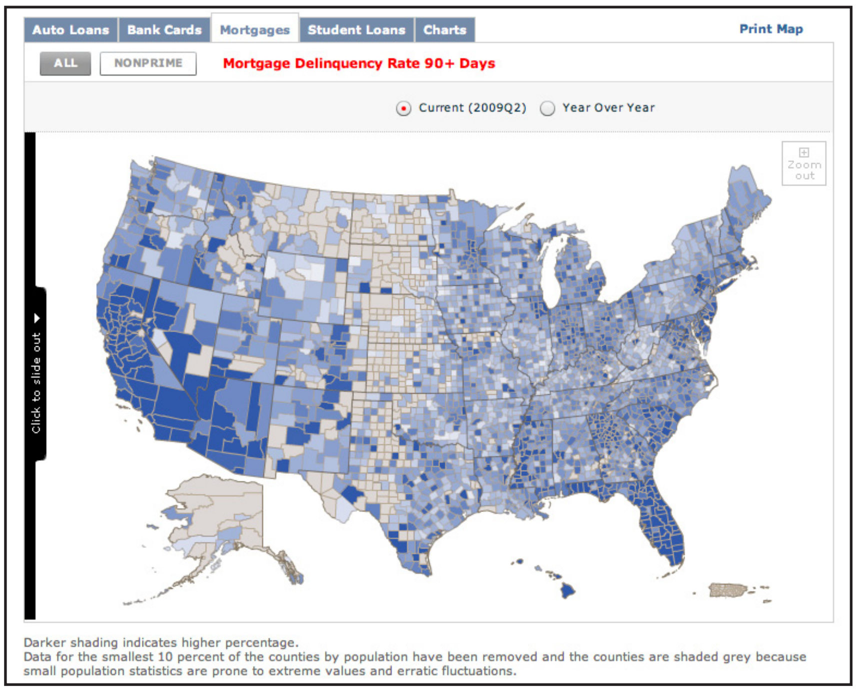


Figure 1.6.
U. S. Federal Reserve map of delinquent mortgages in second quarter of 2009. Note that the high percentage areas are also in states with high growth rates (See Chapter 4).

The ratings organizations that ranked investments called the mortgage backed securities good, because they relied on historical information that the housing market was strong, even though these new mortgage types had never existed before. To make matters worse, the securities often got broken into smaller groups that were then repackaged in to groups known as CDOs, so the higher risk (called "toxic") loans got even greater investment returns. The theory was, the housing

6. Birger, "They Call Them Flippers."
7. BubbleMeter, "A Realtor Bubble?," http://bubblemeter.blogspot.com/2005/08/realtor-bubble.html.

prices would always increase (they had historically), covering whatever risk would be associated with these mortgages.[8] Inevitably, people who couldn't afford these mortgages started defaulting on their loans, foreclosed houses began showing up on the market, and property values started to decline. Even buyers that had good credit and that could afford the payments, seeing their home investment drop began to "strategically default"[9], walking away from a home that had lost so much in value. As the defaults mounted and values declined, the ripple effect up the investment chain caused every step of the process to lose money. The original investors in the pool, tired of losing their investments, stopped providing capital into the system.

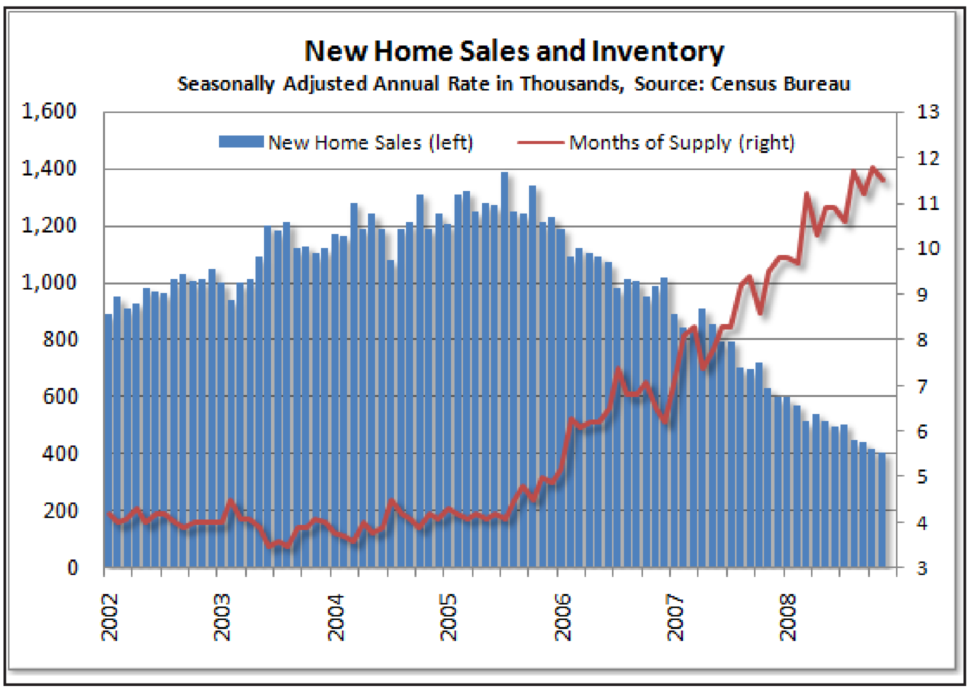


Figure 1.7.

Chart of new home sales and inventory. Note how demand for new homes exceeded supply until the second quarter of 2007.

The developer, geared up to provide housing for the demand, can no longer get the financing to continue developing. The home buyers, many of whose credit was wrecked through the mortgage and foreclosure process, can no longer qualify for a home, at whatever price.

8. Blumberg, "The Giant Pool of Money."

9. Kenneth Harney, "Homeowners Who 'Strategically Default' on Loans a Growing Problem,"http://www.latimes.com/classified/realestate/news/la-fi-harney20-2009 sep20,0,2560658.story.

The investment bank, unwilling to provide the credit to the developer because they no longer have access to investment capital, accepts the land from the developer. The land, now worth half of what it was at the peak of the market, lies fallow, partially owned by a farmer that can no longer plow it, and by a bank that cannot develop it themselves.[10]

Figure 1.8.
New Housing Subdivision and Agricultural Fields, Chandler, Arizona
image © Alex Mac Lean

According to Hanley Wood Marketing Intelligence, a residential development industry analysis organization, currently there are nearly 250 residential development projects in California that have been put on hold. This represents 9,389 residential units worth almost $3.9 billion. Many developers have gone bankrupt, and others have halted sales in an additional 370 new home developments. All told, almost 30,000 units, $11.9 billion worth of projects, have been halted in California alone.[11]

10. Alison Rice, "Delinquencies, Writeoffs for Construction and Development Loans Rise Again," Builder Magazine, http://www.builderonline.com/mortgages-and-banking/delinquencies-writeoffs-for-construction-and-development-loans-rise-age.aspx?cid=BLDR090908002.

11. Roger Vincent, "As Projects Grind to a Halt, Home Sites Turn to Waste-

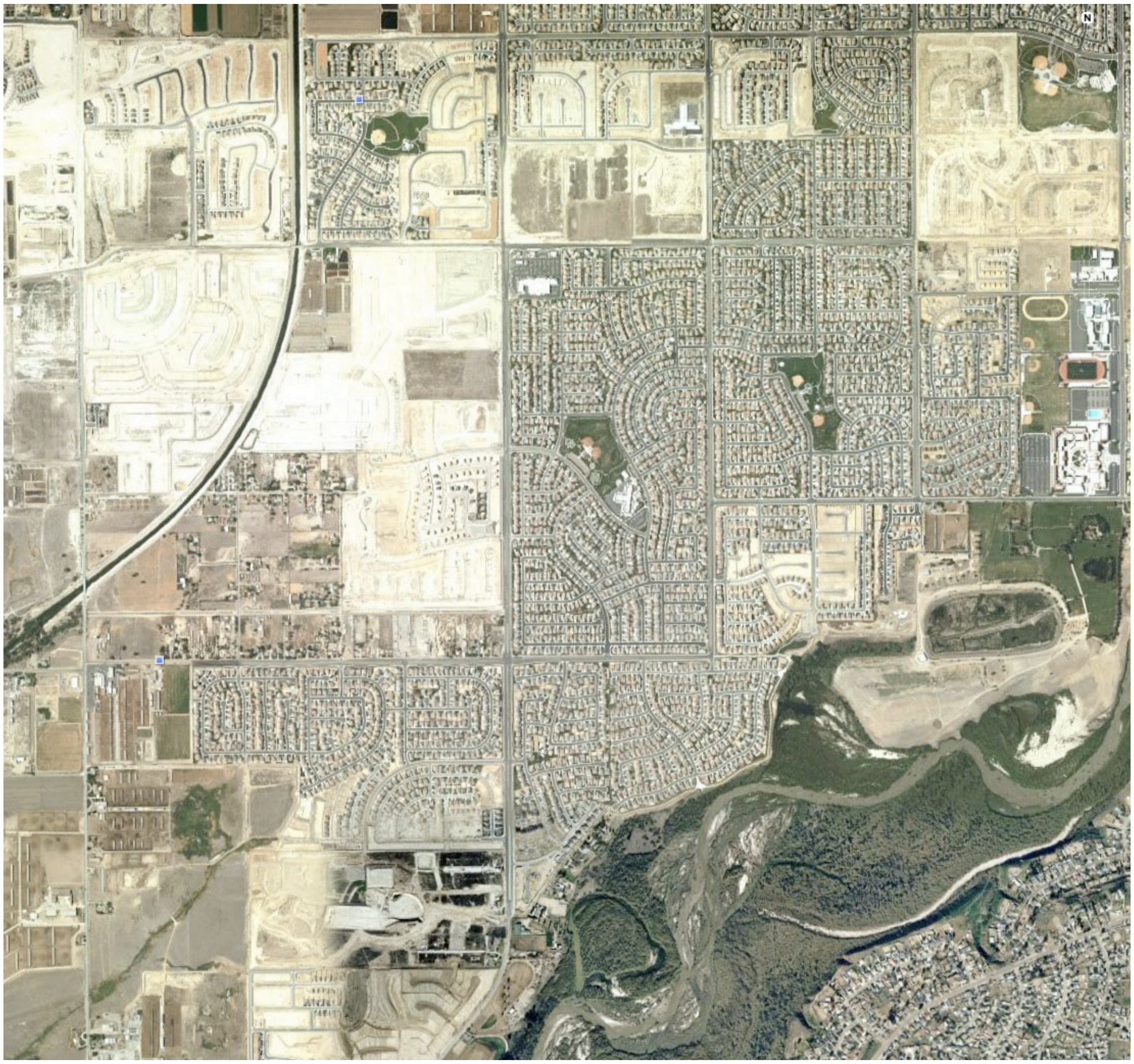


Figure 1.9.
Aerial view of the City of Chino in Riverside County, California, one of the fastest growing areas in the country before the downturn.

land," Los Angeles Times(2009), http://www.latimes.com/business/la-fi-develop4-2009mar04,0,7052529.story.

Introduction

"If one accepts the simple proposition that nature is the arena of life, and that a modicum of knowledge of her processes is indispensable for survival and rather more for existence, health and delight, it is amazing how many apparently difficult problems present ready solution."

Ian McHarg

image © Alex Mac Lean

Suburbia is a dirty word.

The term initially came from sub, as in subordinate to or reliant upon, the urban city. Suburbs were originally the place outside the medieval city walls, the place outside the city center. Then as now, the sub prefix itself carried with it a negative connotation, as in subpar or substandard. Although the meaning of suburban as the portion of the

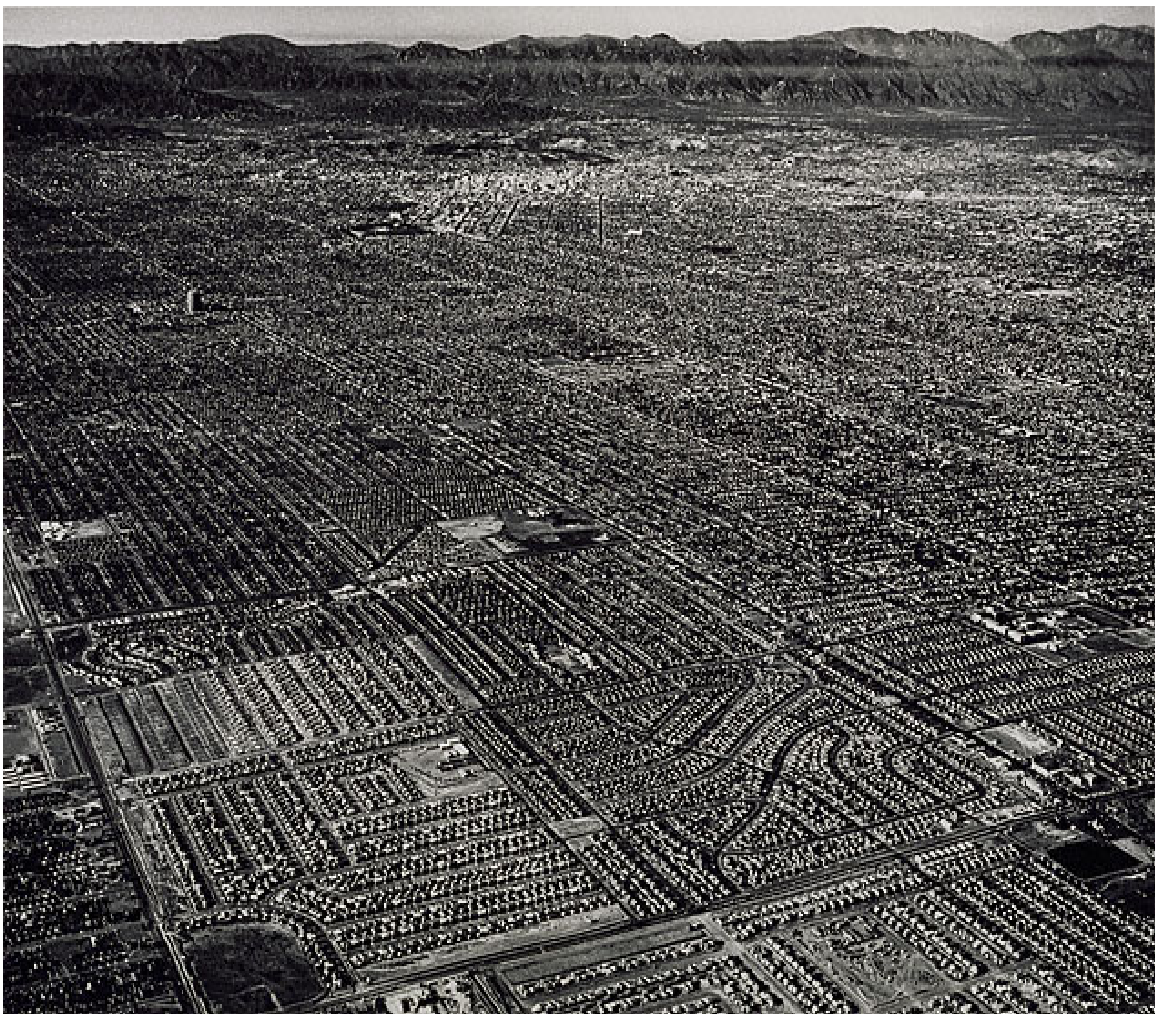


Figure 2.1.
Los Angeles basin 1954
image © William Garnett

urban city on the outskirts often no longer fits, the negative connotation hangs on. In today's context, the term suburban, and the place, suburbia, has come to mean less than urban, that the ideal of urbanity is not achievable in suburbia.

Today's reality in America is that suburbia is no longer subordinate to urbanity. It is, based on growth, the new urban. It is now home to the majority of the country's population.[1] Suburbia is perceived to be the manifestation of the American Dream, and that dream is to live how you want, to be an individual.[2] For the majority of Americans, it means a place in the country with a little bit of land, in a

Figure 2.2.
Large Houses on Small Lots, Plano, Texas
image © Alex Mac Lean

single family house, away from the city and the meddlings of the government it represents.[3] Anthony Flint, in "This Land" quotes Harvard's Alex Krieger of the desire to be "on your own, in your own realm, with easy physical and psychological proximity to the virtues of civilization, while still having access to all things peaceful and pastoral."[4] As more people realize this dream, these dreamers

1. Jon C. Teaford, The American Suburb: The Basics (New York: Routledge, 2008).
2. Dolores Hayden, Building Suburbia : Green Fields and Urban Growth, 1820-2000, 1st ed. (New York: Pantheon Books, 2003).
3. Teaford, The American Suburb: The Basics.
4. Anthony Flint, This Land : The Battle over Sprawl and the Future of America (Baltimore: Johns Hopkins University Press, 2006).

and individualists end up living next to each other farther and farther from the city.[5] These collections of individuals now move based on perceptions of safety, better schools, and on our current consumer tendencies for newness and bigness. The farther from the city, the newer and bigger the house and lot. As they search for the dream, the search requires that they spend more time in the other great symbol of individuality, the automobile. As the suburban enclave grows, utilities and businesses

Figure 2.3.
Large Houses on Large Lots, New England
image © Alex Mac Lean

expand to meets its needs. At a certain point, the suburban dream community often chooses to form its own government.[6] As the individualists collectively demand access to the dream, it becomes necessary to feed the demand. Between 1994 and 2004 that demand was around 1.5 million houses a year.[7] To supply this many houses a year required increasingly larger parcels of available land. Invariably, these larger parcels are further from cities and existing infrastructure. They are typically in the desert, grasslands, farmland or forests,

5. Ibid.
6. Teaford, The American Suburb: The Basics.
7. Hayden, Building Suburbia : Green Fields and Urban Growth, 1820-2000.

and are being developed at the rate of 300 acres per hour.[8] Often these larger parcels are not contiguous, so the smaller or more challenging sites between the large parcels are skipped over in what is known as leapfrog development.[9]

Figure 2.4.
Leapfrog development, Orlando, Florida

8. Flint, This Land : The Battle over Sprawl and the Future of America.
9. Teaford, The American Suburb: The Basics.

The Dream Suppliers.

The entity that satisfies the demand for this American dream is the developer. The single family housing development is typically built by a developer who finds these larger parcels of land and subdivides them into individual house lots.[10] With regional and national sized developers, once the land is subdivided, the developer builds the houses that go on the lots. In smaller developments, often there is a group of small home builders that build the individual homes on the lots and streets provided by the original land developer.

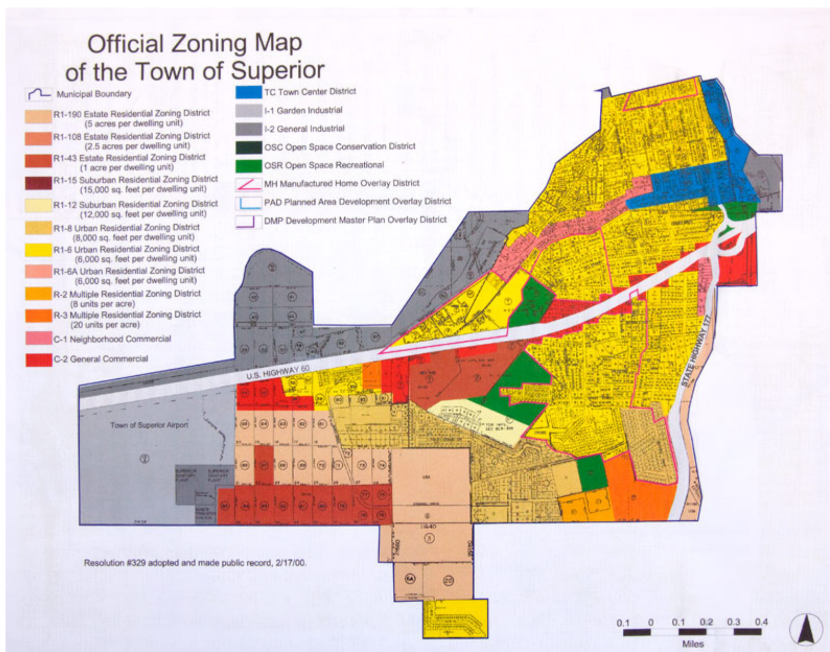


Figure 2.5.

Zoning map example, this one from Superior, Arizona. Note the minimum lot size per residence.

To supply the dream house to the American dreamer is a long and involved process. Development occurs under complex regulations established by the local jurisdiction that has control of the area to be developed as well as state and federal laws. The jurisdiction could be an incorporated city or an unincorporated county. A set of these regulations may include zoning, where land is "zoned" for a particular use.[11] These zones isolate land uses from each other, promoting houses near other houses. Within each zone, specific standards are

10. Marc Weiss, The Rise of the Community Builders: The American Real Estate Industry and Urban Land Planning (New York: Columbia University Press, 1987).
11. Ibid.

imposed that regulate the features within a development, such as streets, the individual lots, and the houses that sit on them. The development site is typically planned out by the developer's civil engineer for the highest number (known as yield) of common shaped, minimum sized single family lots. Streets are laid out to allow as many market desired cul-de-sacs as possible, while meeting public works and fire department access requirements and allow for the streets to carry storm water across the site. This type of configuration stems from standards set by the federal

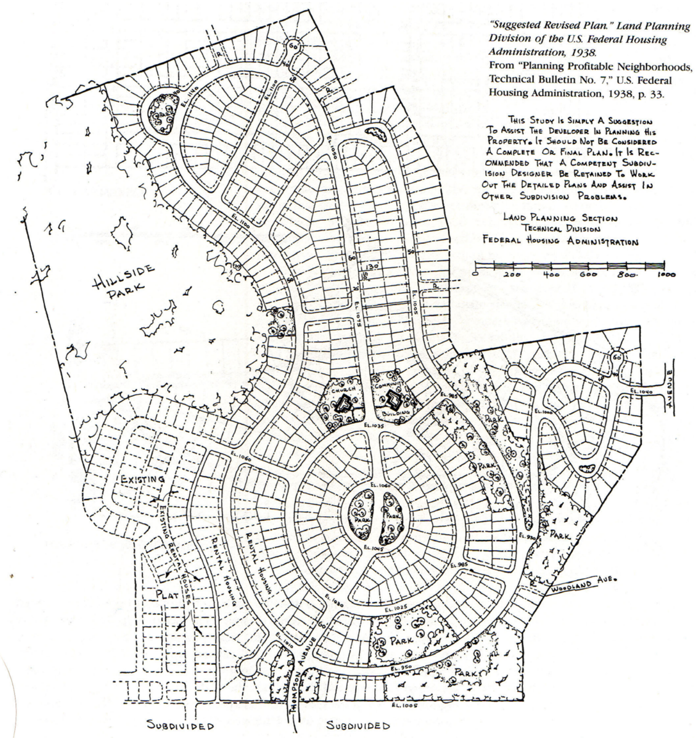


Figure 2.6.
Federal Housing Administration revised plan for a subdivision, 1938

government in the 1930s to promote housing development and insure that developments that follow these standards have access to safe mortgages for homeowners.[12]

A developer typically takes a parcel of land that is zoned for another use, such as farm land, and change its zone to a single family house zone. To do so requires the approval of the jurisdiction through an entitlement process, where the developer is allowed to change the zoning in exchange for fees and other concessions such as utilities,

12. Hayden, Building Suburbia : Green Fields and Urban Growth, 1820-2000.

parkland, schools, or affordable housing that the jurisdiction needs to grow in a planned manner. Throughout the entitlement process, public hearings are held to get input from the residents of the jurisdiction or other interests such as environmentalists or affordable housing and growth control advocates.[13] This process ultimately determines the number of homes, the amenities the project must provide, and the fees required to build the project. The size of the home is determined by the prospective sales price, after taking into

Figure 2.7.
Grading of topography into flat building pads for individual homes. Santa Clarita, California

consideration the amount each house will carry of the cost of the project to provide all of the amenities, fees and utilities for the jurisdiction. A 2004 study in California estimated that the cost of regulatory fees (only a portion of the fees paid) alone accounted for a 30 percent increase in the cost of a house.[14]

Today's suburban home building is the most cost effective way to feed the demand for housing and build what the majority of people want. What the people want is studied in depth by the

13. Teaford, The American Suburb: The Basics.

14. John Quigley, "Regulation and the High Cost of Housing in California," (University of California Berkeley, 2004).

development industry, who looks for features that satisfy the majority of potential buyers.[15] The builders then build to this wish list. In doing so, the number of alternatives to the typical three bedroom two and a half bath single family home is limited. Because alternatives to the actual homes themselves

Figure 2.8.
Housing Development at Different Stages Lakewood, California 1954 image © William Garnett

Figure 2.9.
Housing Development at Different Stages Henderson, Nevada 2004 image © Alex Mac Lean

do not exist, buyers are typically asked about amenities within them. The home building community builds what its surveys determine that the home buying community wants, as such they are truly building to the market.

15. NAHB Housing Economics, "2007 Consumer Preference Survey," ed. Gopal Ahluwalia (2008).

The demand for electricity, gas, and water utility requirements to supply the houses are determined and their sources located. These sources are often quite far from the development site, so the infrastructure for these utilities must be built.[16] The site is then graded for the individual lots, turning natural land forms into flat pads to set the houses on. The homes themselves are then built using materials and construction methods that for the most part have been around for more than fifty years[17]. As such, they consume resources in the same manner as they have since that time.

The result of the land acquisition, design, entitlement and construction process is evident in the built form of the community. To meet the demand for housing, developments are typically on larger parcels of land on the outskirts of existing development. Because the land is being developed in large parcels, by individual developers, continuity and connectedness between developments is usually limited.[18] Guidelines and standards developed by the federal government for street design limit the options for land planning in favor of the automobile and at the expense of sidewalks and walkability. The entitlement process insures the project meets the needs of the jurisdiction's constituents. The houses, updated to the size and amenity level justified through market surveys, are then built with construction techniques as they have been in the past. The result is an isolated homogenous community of single family houses of limited variety accessed only by car.

16. Flint, This Land : The Battle over Sprawl and the Future of America.

17. Renee Y. Chow, Suburban Space: The Fabric of Dwelling (Berkeley: University of California Press, 2002).

18. Michael Southworth, and Ben-Joseph, Eran, Streets and the Shaping of Towns and Cities (Washington: Island Press, 2003).

The Environmental Reality behind the dream.

The single family development practice as it exists today is unsustainable. To continue on this path indefinitely we will run out of resources. The amount of land that gets developed increases yearly,[19] and there is a finite amount of land available for development. The land that is the most optimal for single family suburban development is often the same land that is the most optimal for farming. Single family house size is increasing, and with it the

Figure 2.10.
Housing Development at Congress, Arizona, five miles from the nearest development, sixty miles from Phoenix
image © Alex Mac Lean

amount of land developed per house increases as well.[20] Historically, housing was developed adjacent to the city, where the engine of the economic system was. Now we develop housing on the outskirts, and then bring the businesses and services out to where the houses are, to the detriment of the existing businesses and services within the city. Because these houses, businesses and infrastructure require more land, this puts increasing pressure to develop

19. Henry G. Overman, Puga, Diego, and Turner, Matthew, “Decomposing the Growth in Residential Land in the United States,” (Centre for Economic Performance, 2007).
20. Ibid.

on lands more suitable for farming or habitat or natural resources. Our original cities were built where there was access to transportation and resources such as water necessary to support commerce and housing within them.[21] As the housing moves outward, there is a need to transport those resources out to the houses and businesses via infrastructure.

Housing consumes energy to construct as well as operate it. The construction process requires materials to be manufactured and shipped to the outlying development site. Labor transportation and construction equipment require fossil fuels. The houses themselves consume even more, from electricity, to natural gas, to the gasoline it takes to get anywhere within the suburbs or to the distant city for work. The amount of energy consumed by the suburban single family household has increased faster than the size of the home has increased.[22] In the same time, the size of the single family household has actually decreased,[23] so the energy use per person in the single family home continues upward.

Currently, the majority of electricity in the country is generated by coal fired power plants or natural gas. Coal power plants are considered a "dirty" utility because of their high green house gas production. Producing electrical energy through coal fired power plants is also very inefficient for the amount of coal used.[24] Natural gas, although "cleaner" as a fuel source is a finite fossil fuel, subject to extremes in price volatility because of its often out of the country sources.[25]

21. Flint, This Land : The Battle over Sprawl and the Future of America.

22. Reid Ewing, and Rong, Fang, "The Impact of Urban Form on U.S. Residential Energy Use," Housing Policy Debate 19, no. 1 (2008).

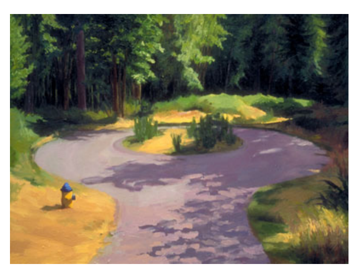
23. U.S. Bureau of the Census, "American Housing Survey for the United States " (2007).

24. Marilyn Brown, Logan, Elise, "The Residential Energy and Carbon Footprints of the 100 Largest U.S. Metropolitan Areas," in Working Paper Series (Georgia Tech Ivan Allen School of Public Policy, 2008).

25. Energy Information Administration, "Summary Statistics for Natural Gas in the United States, 2003-2007," http://www.eia.doe.gov/pub/oil_gas/natural_gas/data_publications/natural_gas_annual/current/pdf/table_001.pdf.

Potable water comes from finite sources, mainly snow pack that feeds streams, lakes, and rivers, and underground aquifers.[26] With global warming, these traditional water sources are becoming increasingly less plentiful. Uncharacteristic drought conditions are occurring across the country, and mountain snow pack in many areas is at historic lows. Because development paves the landscape with impermeable surfaces, rain that would normally percolate into the ground on natural terrain to recharge the underground aquifer is stopped. The majority of rainwater that falls on a site is sent into the storm drain system that flows directly to the ocean, not allow the recharge of the very aquifers we draw water from.

The suburban single family home development is produced by a developer meeting the demand for this type of housing. The homogeneous nature of the single family housing produced is a direct result of meeting the challenge of trying to satisfy all of the conditions placed on the project from other sources. The design, approval, financing and construction of these developments follow patterns that have been in place for generations. The developer must follow the path of least resistance. Today, this path is no longer environmentally sustainable. This will require that development is done differently. The demand to achieve the American dream remains. It is time to offer alternatives for what that dream means. It is time to achieve the supplying of that dream in a more environmentally sustainable way. Providing housing in alternative forms. Using less land per housing unit. Insuring that the housing produced is not wasteful with energy and water resources. Providing all of this in a way that does not require a car so much and allows the community of individualists to share common spaces and opportunities. The negative connotation of the word suburbia does not limit the amount of Americans who want to live there. It is now time to change what suburbia means, to change the dirty word once and for all…



26. Susan Hutson, et. al.,, “Estimated Use of Water in the United States in 2000,” (Denver: U.S. Geological Survey, 2005).

Liberty & Sustainability

"Rightful liberty is unobstructed action according to our will within limits drawn around us by the equal rights of others"
Thomas Jefferson

"The future belongs to those who understand that doing more with less is compassionate, prosperous, and enduring, and thus more intelligent..."
Paul Hawken

The Libertarian Dream.

The single family house in suburbia represents many things. It is a symbol of choice, that you have chosen to live where you want. In suburbia, that choice is seen as a home in the country, implying that you are closer to the wilderness. It represents freedom, at a distance from big city government, where you are free to pursue happiness. It represents personal wealth. Living in suburbia signifies that you are a success. It represents your power of choice as a consumer. Americans look for newness, and often will choose a new house in a new community over an older home in an established neighborhood. It represents freedom to associate with others, living in a neighborhood with people just like you.

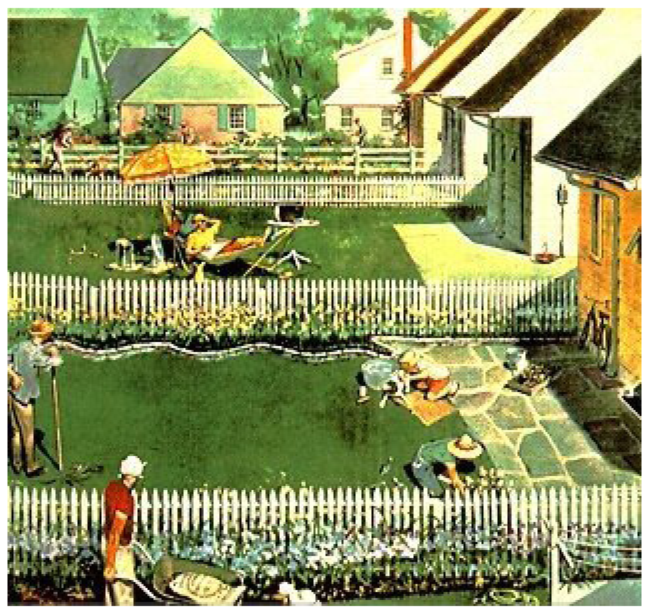


Figure 3.1.
The American Dream

The idea of the single family home in small town is not a new one, and stems from our earliest days as a country with a vast continent to explore. Thomas Jefferson, one of our country's founding fathers, could be considered the godfather of sprawl.[1] He believed that agriculturally-based small landowners in rural wards dispersed throughout the country could govern themselves better than a central, city-based government could. Later, Frank Lloyd Wright in his Broadacre City had a similar idea. Jacquelin Robertson

1. Anthony Flint, This Land : The Battle over Sprawl and the Future of America (Baltimore: Johns Hopkins University Press, 2006).

in "*The Seaside Debates*" wrote, "the essential theme of their [Jefferson and Wright's] Arcadian communities was that of an idealized domesticity, with the individual house not only as the center of urban life but also as the city's most representative secular temple…the house was the city." [2]

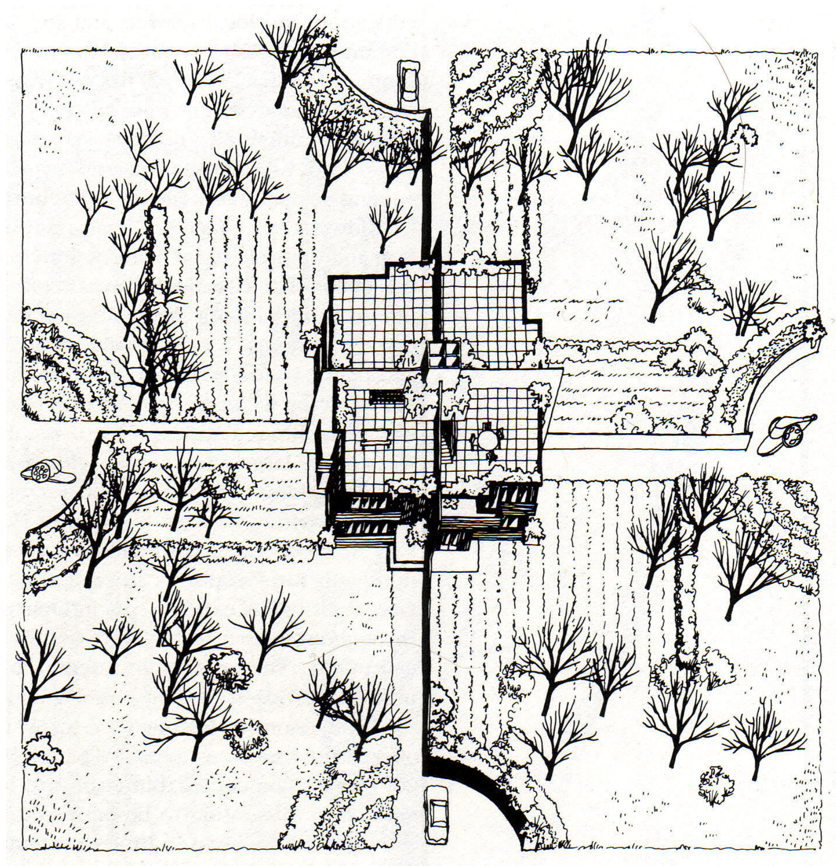


Figure 3.2.
Frank Lloyd Wright's Broadacre Houses

Taken to the extreme in today's suburban environment, James Howard Kunstler notes in "Home from Nowhere" that "the current popular conception of democracy finds physical expression not in neighborhoods, towns or cities, but only in individual homesteads."[3]

2. Todd Bressi, The Seaside Debates: A Critique of the New Urbanism (New York: Rizzoli International Publications, 2002).

3. James Howard Kunstler, Home from Nowhere : Remaking Our Everyday World for the Twenty-First Century (New York: Simon & Schuster, 1996).

In *The American Suburb*, Jon Teaford counters the home as democracy view, explaining that suburban communities historically incorporated into their own cities, because they "seek to define the destiny of their own communities free from state meddling. From the standpoint of efficiency or equity, American suburbia may not make any sense. Yet Americans perceive suburban self-determination as a vital component of the nation's heritage of liberty. The political fragmentation of suburbia is as American as apple pie, hot dogs, and the flag."[4]

Figure 3.3.
Levittown lawn
Levittown, NJ is considered the first large scale post war suburban development

At the turn of the century, the home as an individual dwelling in the landscape was strengthened as a reaction to the ills of city life. With it too was a strengthening of notions of liberty, of the ability to live life as one chose. "Suburbia is the site of promises, dreams and fantasies…where Americans situate ambitions for upward mobility and economic security, ideals about freedom and private property, and longings for social harmony and spiritual uplift."[5] After

4. Jon C. Teaford, The American Suburb: The Basics (New York: Routledge, 2008).

5. Dolores Hayden, Building Suburbia : Green Fields and Urban Growth, 1820-

World War Two, the American Dream developed into the single family house as a reward for sacrifice and hard work (especially for returning GIs), aided by an increasing affluence and development of a materialistic way of life.

Dolores Hayden, in "*Building Suburbia: Green Fields and Urban Growth 1820-2000*" speaks of the triple dream: a house as a place of happiness, with a neighborhood sociability, in unspoiled nature. She noted though that these new developments were

Figure 3.4.
Levittown @ Route 13

no longer the work of town fathers or planners but that for the most part the realization of this dream was now in the hands of developers and the promoters of growth which included utilities, transportation companies, and supermarkets. "The history of suburbia has been a struggle between residents who want to enjoy it and developers trying to profit from it."[6] Robertson writes "By 1950, we were rich and happy to be

2000, 1st ed. (New York: Pantheon Books, 2003).

6. Ibid.

away from the tiresome constraints of war, one of which was the discipline of planning. We went on a binge of building agglomerated objects, not planned settings… We planned carefully and won the war, but we did not plan carefully after that and thus lost the peace."[7]

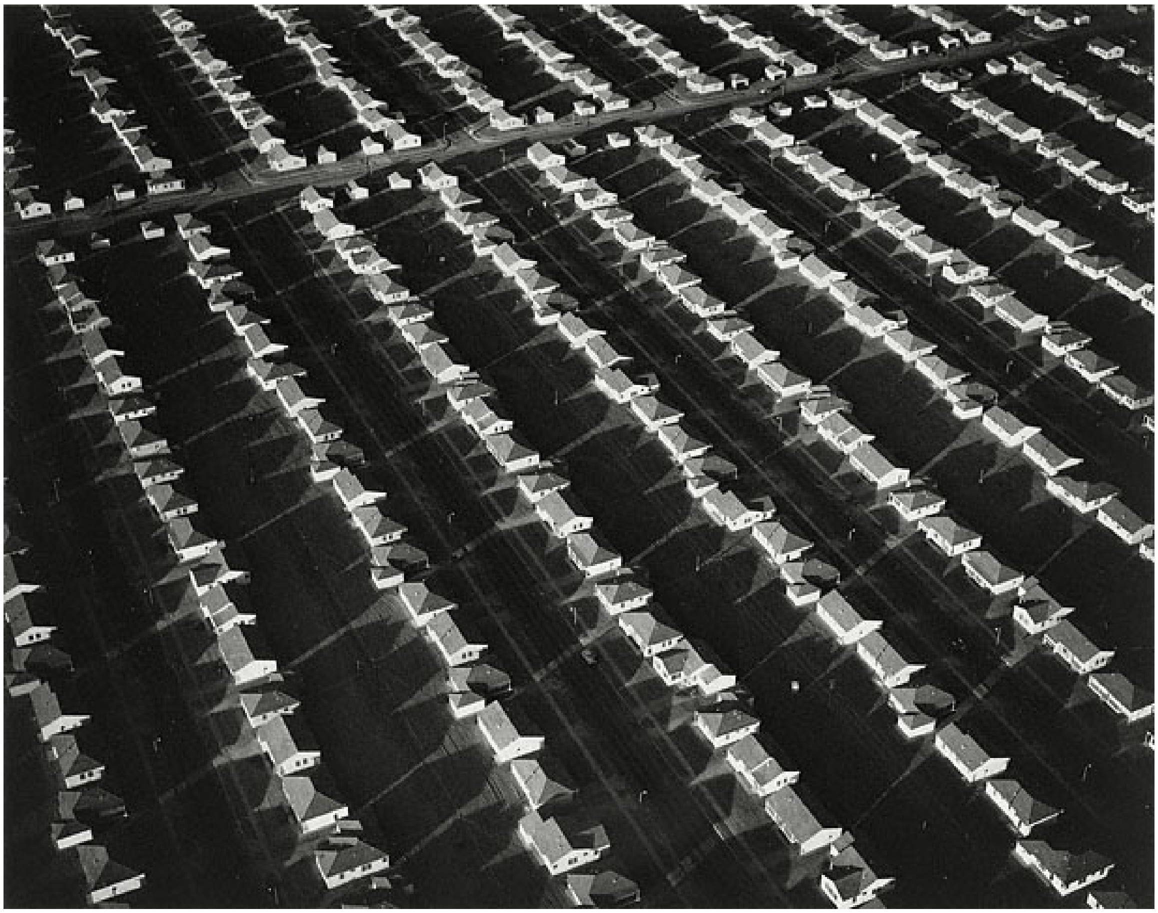


Figure 3.5.

Lakewood, California 1947
image © William Garnett

Today if you follow the critics, of Hayden's triple dream: the house has become a product, nature has been spoiled by the amount of houses within it, and a singular housing arrangement has promoted isolation, not neighborliness. Kunstler writes, "One can hardly conceive of a system more conducive to an extreme form of individualism and less supportive of any notion of the common good,"[8] and

7. Bressi, The Seaside Debates: A Critique of the New Urbanism.
8. Kunstler, Home from Nowhere : Remaking Our Everyday World for the Twenty-

"No people on earth brag so much about their equality and no people spend as much time and energy trying to prove they are better than the next guy."[9] As for the design of suburbia, in "*This Land*" Anthony Flint opines, "For something so primary-something we see everyday, something that dictates how we live and function, that has a direct influence on our attitudes and moods-the American landscape is shaped with very little intention."[10]

Figure 3.6.
Rear yards
Henderson, Nevada
image © Getty Images

Today, although a city may indicate where it wants a certain land use, the actual development of the built environment is determined largely by the developer who proposes the project in the first place. But even the developer has limitations on building what is in the best interest of the community. Often an outsider to the city they are developing in, they must balance the need for providing housing with the tasks of dealing with investors, mortgage lenders, politics, and militant local residents who see any developer, no matter how well meaning, as the antichrist. Today also, the design professionals that take part in these developments rarely participate interdisciplinarily with

First Century.

9. Ibid.

10. Flint, This Land : The Battle over Sprawl and the Future of America.

each other, a practice that corresponds with the splitting of these disciplines within universities post Second World War[11]. Land planning of today's suburban single family subdivision site is driven most often by the civil engineers within the design professional team. The engineers lay out the site for the maximum lot yield proposed by the developer filtered through strict requirements for grading, utilities, fire department access, traffic speeds, stormwater quality and runoff and the developer's budget. The architects then place the three house types within the lots, and the landscape architect greens the spaces left over and in between. As a result, in suburbia "the trail of errands is long, because single family zoning is too rigid and the regulatory system in mortgage banking has formed around the sale and resale of one kind of house for one kind of family."[12]

Prior to the economic issues we face today, much of American's worth was tied up in their homes, to the point that housing stock within the United States was estimated to be worth $24.1 trillion at the end of 2005.[13] The real estate industry reinforces the notion that a home is a safe investment and a tool for consumption. A report by the National Association of Realtors "*Housing: an Investment and a Piggy Bank for Spending*"[14] encourages consumption using the equity in your home. Since the 1980s, as the price of the single family house rises, the amount of people that can afford one declines, and with it comes a resentment and a feeling of entitlement, that every American deserved the American Dream. The reality is that less and less people can achieve it.

11. Bressi, The Seaside Debates: A Critique of the New Urbanism.
12. Hayden, Building Suburbia : Green Fields and Urban Growth, 1820-2000.
13. Morris Davis, and Heathcote, Jonathan, "The Price and Quantity of Residential Land in the United States," (Wisconsin: University of Wisconsin-Madison, 2006).
14. National Association of Realtors, "Housing: An Investment and a Piggybank for Spending," (2003).

Much has been written recently about the ills of suburbia, especially from those in traditional town planning and New Urbanist circles (a typical example, from Kunstler, "suburbia fails us in large part because it is so abstract, it's an idea of a place, not a place."[15]). The predominant feeling is that if we return to traditional town planning and densely living in the city as is promoted by the New Urbanism movement, all will be well. In a critique of New Urbanism though, Amanda Rees writes "alienating everyone already living in post World War II suburbia by simply labeling their physical, social, and cultural environment as "bad" does little to persuade people of (New Urbanisms) merits".[16] It appears a missing argument in these discussions is that today, most of the people living in suburbia have not experienced any other living conditions in their lifetimes. Often they are the second or third generation since the Second World War to have lived in a single family suburban tract house. Many of the critics of suburbia grew up in (and in most cases still live in) vibrant cities, and have memories of them. Most suburban dwellers do not have these types of city memories, but have their own in the suburbs. As Renee Chow points out in "*Suburban Space: the Fabric of Dwelling*" "the postwar suburbs are cited as the cause of waste, isolation and commodification in ways of living; on the other hand their mass production has only made that culture more accessible".[17] So the success of any movement toward future density and city living must overcome this obstacle. Or, as the research might suggest, there is a way to make suburban living sustainable.

15. Kunstler, Home from Nowhere : Remaking Our Everyday World for the Twenty-First Century.
16. Matthew Lindstrom, Suburban Sprawl: Culture, Theory and Politics (Lanham: Rowman and Littlefield Publishers, Inc., 2003).
17. Renee Y. Chow, Suburban Space: The Fabric of Dwelling (Berkeley: University of California Press, 2002).

Sustainability Defined and Research Focused.

The most often quoted definition of sustainability is that of the Brundtland Report.[18] It defines sustainable development as "development that meets the needs of the present without compromising the ability of future generations to meet their own need." Sustainability, as will be used in this research, will be the ability to provide for an increased efficiency of land use, a net zero source energy use, efficient use of water, reduced utility loads, reduced car use and increased community connectivity as compared to the current model.

Figure 3.7.

Four Converging Paved Cul-de-Sacs Houston, Texas image © Alex MacLean

The focus of this research is to provide an alternative development strategy for fallow sites. As such we have to establish certain criteria regarding those sites, and their relation to sustainability and development. First, this research assumes that a fallow site exists, that the site has been disturbed. Although the opportunity exists for this research to be adapted to brown field sites and infill sites as well, the impetus for the research is that these

18. United Nations World Commission on Environment and Development, "Our Common Future," (Oxford: Oxford University Press, 1987).

sites have already been graded or the land disturbed. As such, the research is not suggesting that these concepts be applied initially to undisturbed greenfield sites, without first determining that other brown field, gray field, or infill sites are not available.

A common and serious concern with single family suburban development is that of regional transportation connectivity. The majority of these sites are assumed to be once-greenfield land on the outskirts of the jurisdiction they reside in. As such, they are commonly only accessible by automobile. The concept of regional transportation connectivity is a substantial subject worthy of its own study, and too large to include within the scope of this research within the time frame available. This is not to say that it will be ignored, but the research will focus on the opportunities within the suburban block to use pedestrian and bicycle transportation to connect to the balance of the neighborhood, and by providing places to introduce multi-use business opportunities within the block, creating the potential to not have to use a car (or use it substantially less) to get to work or services by having those uses within the neighborhood.

These multi-use business opportunities also begin to address the idea of economic sustainability. Again, this topic is worthy of study in and of itself, and true evaluation of the economics of businesses locating within these spaces is not part of this research. Economic sustainability plays a part in social equity also, a concept within overall sustainable development. To the extent that the research will look at providing smaller homes and multiple housing opportunities within the block, the ability to have people from differing economic strata live within the same neighborhood is possible. It will not be addressed beyond that within this research.

Returning to Brundtland, it goes on to state that "sustainable development requires those who are more affluent to adopt lifestyles within the planet's ecological means."[19] Rephrased another way by Jeffrey Harris in "*Don't Supersize Me*" he says, "rather than having developing countries learn to be efficient from the United States, the United States might learn from other countries to have lower energy-intensive lifestyles."[20] This brings forward the notion of changing our lifestyle for the future of our children and the planet. There is significant discussion in the "sustainability community" about the idea of sacrifice. Many believe that using this terminology implies that there is a trade off between sustainability and lifestyle, and asking the public to alter their lifestyle will doom the move toward sustainability. The time has come to move away from the mindset of the individual and toward a more common good, especially as it relates to the environment. Single family suburban development does not offer a wide choice of housing or lifestyle. It is the intent of the research to provide that choice in the redesign of the suburban block, and that in choosing to occupy this new type of development, the homeowner is making environmental choices for the common good as well as providing for their individual shelter. Americans will still be at the liberty to choose where and how they live, but in a framework of sustainable options.

19. Ibid.

20. Jeffrey Harris, et. al, "Don't Supersize Me! Toward a Policy of Consumption-Based Energy Efficiency," in ACEEE Toward Zero Energy Buildings (2006).

Suburbia Today

"If we could first know where we are, and whither we are tending, we could better judge what to do, and how to do it"

Abraham Lincoln

image © Alex MacLean

Land Use.

The total land in the United States is nearly 2.3 billion acres. Of that, 154 million acres (6.8 percent of the total) are developed as urban and rural residential lands.[1] Some contend that the amount of land that is developed is small compared to the amount of land within our boundaries. Conservative organizations such as the Heartland Institute and the Lone Mountain Compact feel we should have the freedom to develop as we see fit.[2] But a closer look reveals that the land we typically do not inhabit is land we choose not to (or cannot) inhabit because it is inaccessible, too hot, too cold, too mountainous or too dry.[3] In addition, 40 percent of the land in the United States is owned by the individual States, the Bureau of Indian Affairs, or the Federal Government.[4]

The population of the United States is expected to grow from approximately 300 million today to an estimated 420 million by 2050. The five states with the largest population growth in 2004 (California, Texas, Florida, Arizona and Georgia) accounted for 53 percent of the growth. California, the most populous state at roughly 36 million people (2005) is expected to grow by 15 million people between 2000 and 2030 (a population the size of the entire state of Florida in 2000), and expected to hit 60 million by 2050.[5] If we continue to use land in the same way we have in the recent past to house this growth, consider this: Picture a football field. Then picture it multiplying every second, twenty four hours a day every day for three years. That is how much land we are going to need.[6]

1. Ruben N. Lubowski, et.al., "Major Uses of Land in the United States, 2002," ed. USDA Economic Research Service (2006).
2. James and Bast Taylor, Joseph, "Environmental Policy and Freedom," http://www.heartland.org/suites/environment/index.html.
3. Anthony Flint, This Land : The Battle over Sprawl and the Future of America (Baltimore: Johns Hopkins University Press, 2006).
4. Lubowski, "Major Uses of Land in the United States, 2002."
5. Robert Bernstein, "Nevada Edges out Arizona as Fastest-Growing State," (U.S. Census Bureau, 2005).
6. Flint, This Land : The Battle over Sprawl and the Future of America.

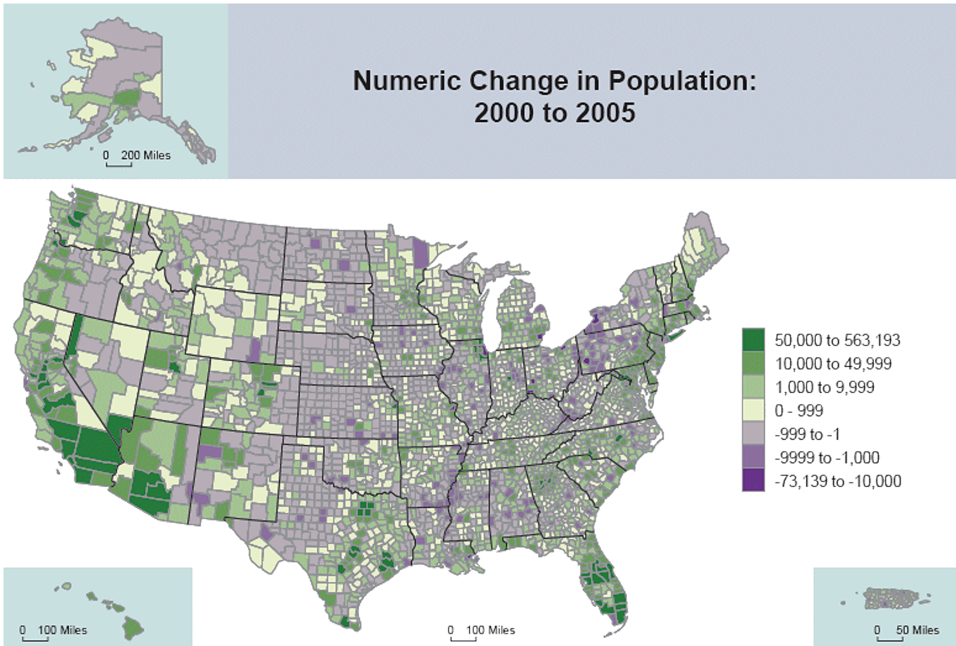


Figure 4.1.
U.S. Census Population Growth

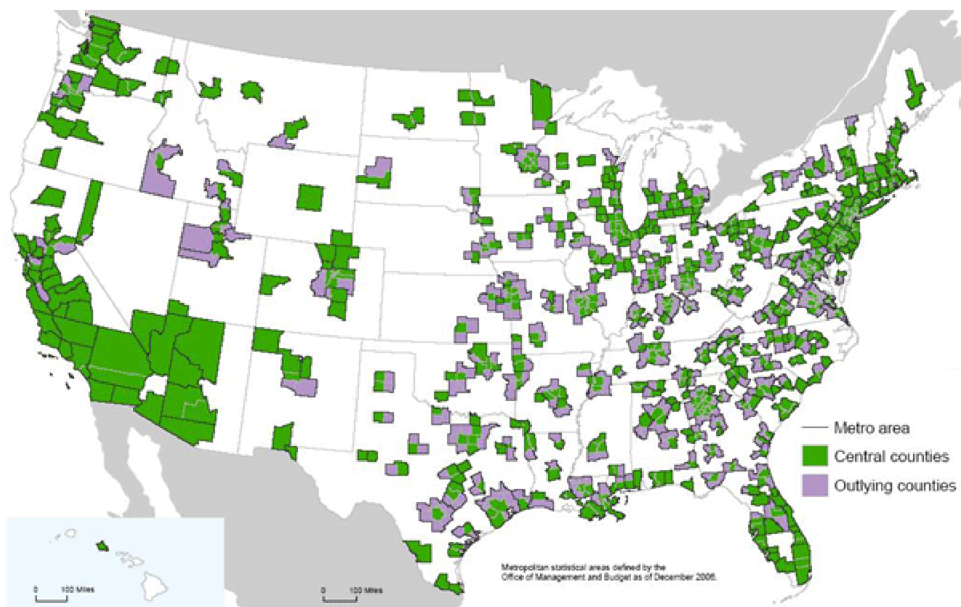


Figure 4.2.
U.S. Census Population Growth in Suburban Areas

Although we consume increasing amounts of land to house the growth in population, the land is not seen without value. Between 1975 and 2006, the value of the structure of an individual single family home increased 33 percent. In that same time period, the value of the land increased 400 percent.[7] Changes in house prices are attributed to the change in land value, not in the value of the structure. This illustrates that the structure of a home is replaceable, the land is not. By 2006, the value of the land accounted for 46 percent of a home's value,[8] an increase from 20 percent around the Second World War. It also illustrates why the suburbs continually push outward from metropolitan areas, the growth moves in the direction of less expensive, plentiful sources of land. It also predicts that, as land becomes more scarce, the price of a home will increase to keep pace, further affecting home affordability.

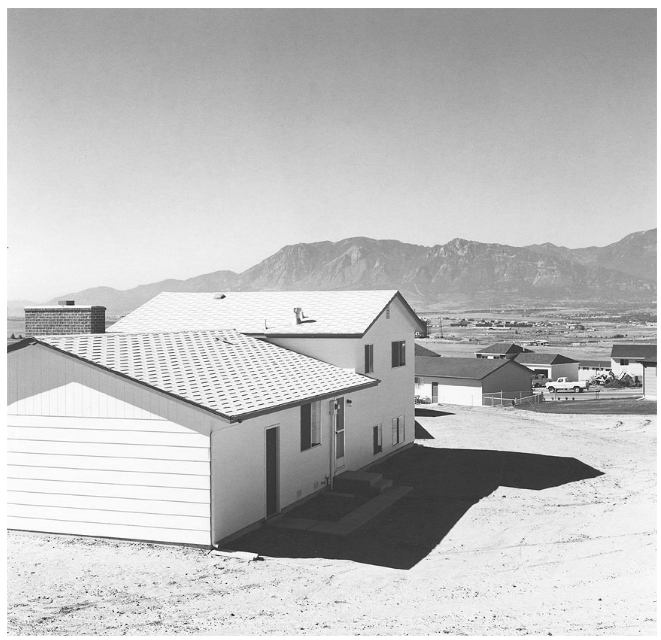


Figure 4.3.
Newly Completed Tract Homes, Colorado Springs, CO 1968 image © Robert Adams

Other factors contribute to why we build so many houses. According to the U.S. Postal Service, the average American now moves eleven times in their lifetime.[9] Prior to the second world war, you grew up in a house within a neighborhood. You got a job and bought a house, often in a neighborhood close to the one you grew up in. You raised your kids, worked until retirement from your job and aged in place in the same house. Today no one stays

7. Morris Davis, and Heathcote, Jonathan, "The Price and Quantity of Residential Land in the United States," (Wisconsin: University of Wisconsin-Madison, 2006).
8. Ibid.
9. Flint, This Land : The Battle over Sprawl and the Future of America.

at a job for more than five or ten years, and they usually transfer to another city with each job. With each successive child comes the implication that each child must have their own bedroom, so you move again. Once the kids are gone, you need to move again, because you've earned the right to live as you want. Even if you wanted to downsize, current federal tax structure under certain circumstances penalizes non-retirement age persons purchasing a home that is significantly less expensive than the one they just sold with capital gains taxes. This high turnover and tax structure now drives the decision to purchase larger houses; the number of bedrooms and bathrooms is not based on the actual needs of the current residents.[10]

As the house size increases, the land used for housing is increasing also, but at a faster rate. In the United States between 1976 and 1992, the amount of land built upon for residential use increased by 47.5 percent. During the same time period, the population grew by only 17.8 percent[11]. This can be attributed to several factors. First there is an increase in the amount of land use per person, being driven by houses being built in areas where houses are typically bigger on larger lots. Next, the growth of non-traditional households (single parents with kids, kids moving out, adults with no kids, etc.) has created growth in the number of houses required to house the population. During the period studied, household size declined from 2.97 to 2.69 persons per house. Thirdly, the areas of the country where population increased the most were areas where the land used per person is the highest. The most extreme of these cases was Florida, where the residential land per person was twice the national average, and the population increased three times as much as the rest of the country[12].

10. Jeffrey Harris, et. al, "Don't Supersize Me! Toward a Policy of Consumption-Based Energy Efficiency," in ACEEE Toward Zero Energy Buildings (2006).
11. Henry G. Overman, Puga, Diego, and Turner, Matthew, "Decomposing the Growth in Residential Land in the United States," (Centre for Economic Performance, 2007).
12. Ibid.

Regulation and Land Use.

The land use patterns of suburban development in the United States may have begun at the turn of the nineteenth century, but a series of moves by the Federal Government just prior to the Second World War sealed this type of development in place where it remains substantially unaltered today. Urban development has become a continuous economic and political process, and with federal supports has consistently favored new construction of single family residences.[13]

Modern zoning, where functions of society and the uses of the land are separated, grew out of the need to separate noxious, unhealthful uses from housing, and regulate intensities of uses on property. The City of Los Angeles passed the country's first zoning law in 1908.[14] This type of zoning is

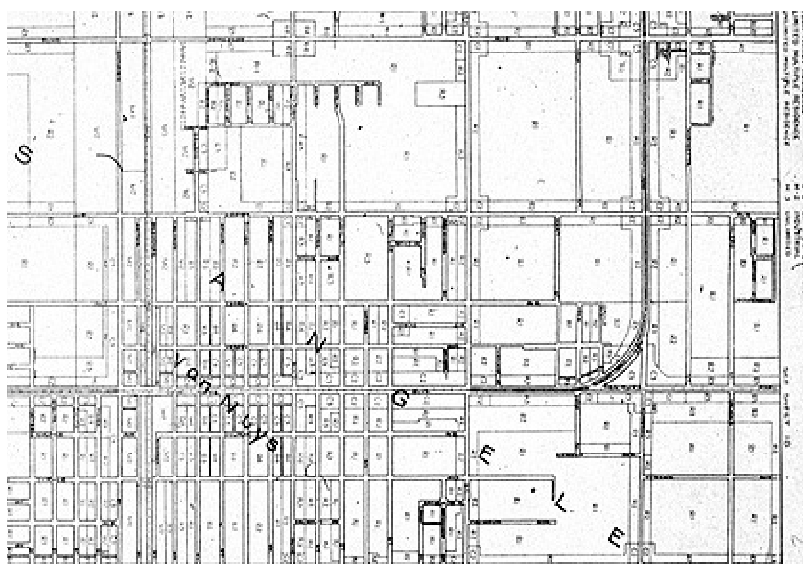


Figure 4.4.

Zoning map example, Van Nuys area of Los Angeles, 1942

known as Euclidian zoning, named after the town of Euclid, Ohio that successfully upheld the constitutionality of zoning land uses in the U.S. Supreme Court in 1926 (*Euclid vs. Ambler Realty Co. 272 U.S. 375*).[15] It has been in use throughout the

13. Dolores Hayden, Building Suburbia : Green Fields and Urban Growth, 1820-2000, 1st ed. (New York: Pantheon Books, 2003).
14. Marc Weiss, The Rise of the Community Builders: The American Real Estate Industry and Urban Land Planning (New York: Columbia University Press, 1987).
15. William B. Fulton, Guide to California Planning, 2nd ed. (Point Arena, Calif.: Solano Press Books, 1999).

country ever since. Taken one step further in the suburbs, Los Angeles also established the first single family zoning district designation in 1921, setting up a nationwide legal precedence for this use.[16] Today, even single family residential areas are often "zoned" into separate areas based on the sizes of the houses within differing neighborhoods.

The Federal Housing Administration (FHA) was established in 1934 and in part it provided a vehicle for low down payment, long term mortgages to purchase homes. The intent was to increase the number of citizens that could afford a home with federally insured mortgages. The driving force though, was "to stimulate the building industry, to gain the confidence of private lenders including the nation's largest insurance companies as well as local savings and loan associations, and to ensure a sound and solid foundation for private real estate investment."[17] As reported by the FHA, in 1940, California had twice as many mortgages as any other state, and 83 percent of them were for newly constructed single family residences. Of the 2,680 subdivisions it reviewed throughout the country, 70 percent were newly built, and 98 percent of them were exclusively single family developments. [18] In reality, these loans ended up focused in "low-risk" areas: single family, low-density predominately white suburbs.[19] [20]

In 1936 and 1938 respectively, the FHA published technical bulletins: "*Planning Neighborhoods for Small Houses: Technical Bulletin No. 5*" and "*Planning Profitable*

16. Weiss, The Rise of the Community Builders: The American Real Estate Industry and Urban Land Planning.

17. National Register Publications, "Suburban Landscapes: The Federal Housing Administrations's Principles for Neighborhood Planning and the Design of Small Houses," (U.S. Department of the Interior).

18. Weiss, The Rise of the Community Builders: The American Real Estate Industry and Urban Land Planning.

19. Kenneth T. Jackson, Crabgrass Frontier : The Suburbanization of the United States (New York: Oxford University Press, 1985).

20. In fact the FHA underwriting manual encouraged use of deed restrictions to maintain "homogenous" populations within FHA financed subdivisions. Race restrictions were later struck down by the U.S. Supreme Court in 1948.

Neighborhoods: Technical Bulletin No. 7". These set standards for the design of subdivisions that were to be financed through the FHA, and were influenced by Clarence Perry's Neighborhood Unit concept.[21] [22]

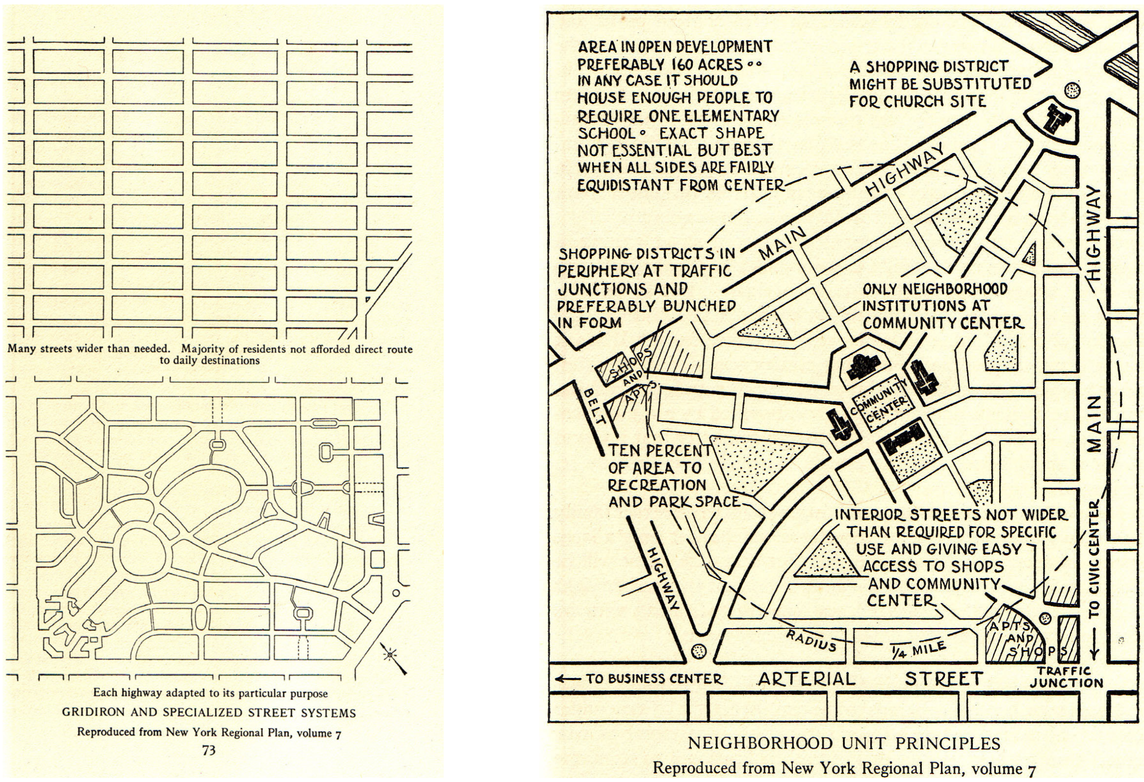


Figure 4.5.

Illustrations in Clarence Perry's "Housing for the Machine Age" 1939.
The diagram on the right is a major influence today on the New Urbanist Movement

The FHA had a set of minimum requirements that determined the location, accessibility, utilities, zoning, home values and financial stability of the builder. Plans for projects funded by FHA were sent through the Land Planning Division who often redesigned the projects to meet their criteria. Through their designs and within these guidelines are many of the hallmarks of suburban planning that are still in use today: Standard lot sizes and street widths, setbacks, curvilinear streets, and the cul-de-sac. The turn from the rectilinear street grid to curvilinear streets was meant to foster a sense

21. National Register Publications, "Suburban Landscapes: The Federal Housing Administrations's Principles for Neighborhood Planning and the Design of Small Houses."

22. Clarence Perry, Housing for the Machine Age (New York: Russell Sage Foundation, 1939).

of community by providing interesting streetscapes, made more harmonious by limiting the number of house designs. Through traffic was discouraged, as was non-residential uses or other types of housing than single family homes

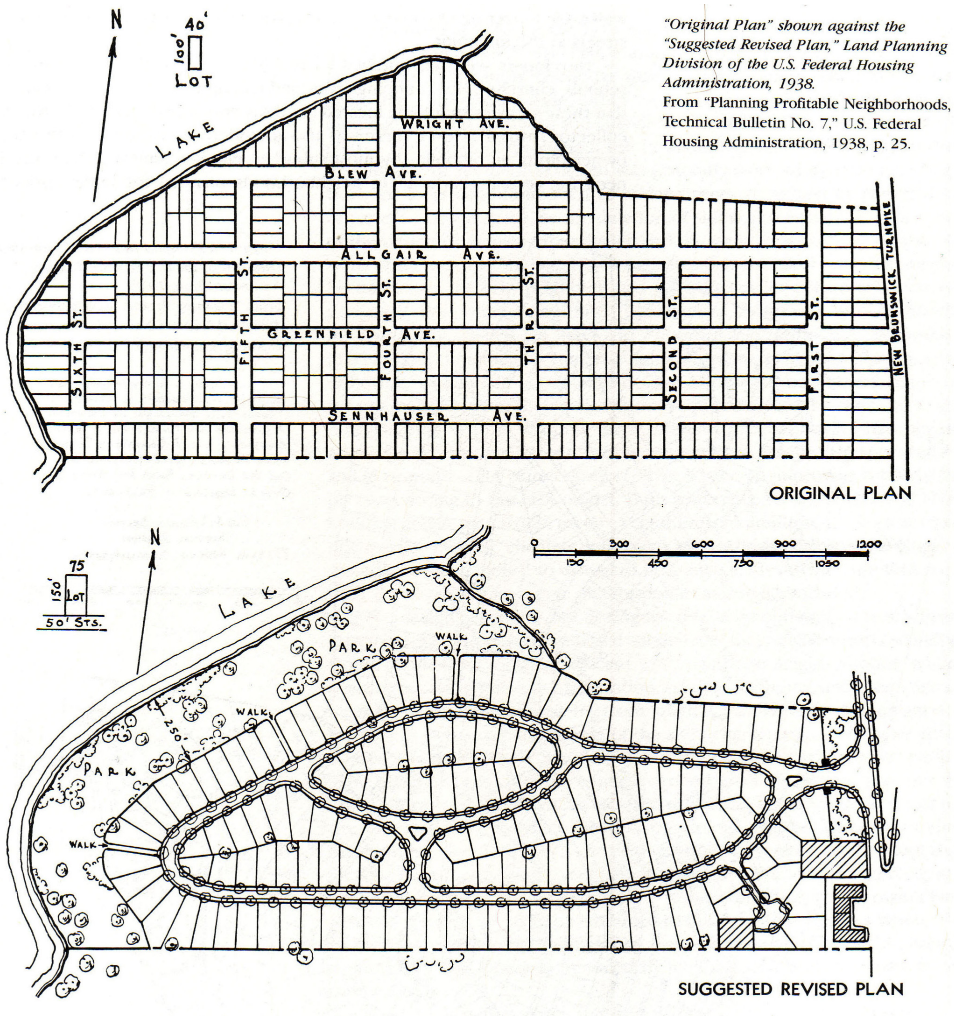


Figure 4.6.
Federal Housing Administration revised plan for a subdivision, 1938 from "Yard, Street, Park" by Girling and Helpland

Cul-de-sacs led to minor streets and courts which connected to collector roads in a distinct hierarchy, with street widths matching intensity of vehicular use. It was thought that this development pattern provided for the highest yield of lots, especially in oddly configured sites, and was safer because it lacked multiple intersections. It was also seen as a cheaper way to build infrastructure, with less paving and shorter utility runs.[23] Another main component to these standards

23. National Register Publications, "Suburban Landscapes: The Federal Housing Administrations's Principles for Neighborhood Planning and the Design of Small

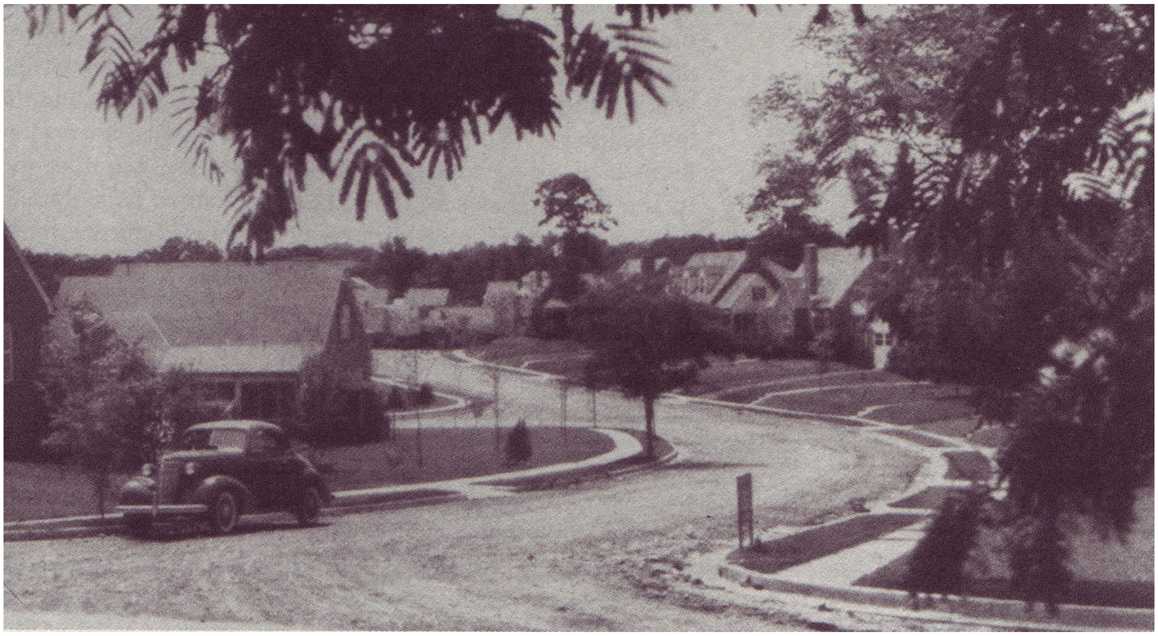


Figure 4.7.

FHA Technical Bulletin #7 1938 Image shows how the FHA implied the neighborhood would look based on their standards.

was the encouragement of large scale development under an "operative builder". This method was said to provide a "broader and more profitable use of capital" that allowed standardization and efficiencies in planning and construction of the homes, and allow the builder to provide "commercial services such as retail stores and gas stations necessary to the life of the new community".[24]

Figure 4.8.

How the FHA standards look today

Houses."

24. Ibid.

In 1956, the Federal Interstate Highway Act provided $25 billion in federal funds to construct 41,000 miles of interstate highways. President Dwight Eisenhower saw the need to be able to effectively move military vehicles and evacuate civilians across the country in the event of military conflict. The result of this was that substantial areas of land across the country were now made accessible by car, and thus available for suburban development.[25]

Figure 4.9.
US 375 in Allen Texas 1959

25. Flint, This Land : The Battle over Sprawl and the Future of America.

Subdivision design elements.

The development process begins with a developer finding a willing landowner to sell their land. It may be a single parcel, or a combination of parcels with a combination of landowners. The price of the land is determined by the "yield", how many housing units can be placed on the site. The larger the site, the higher overall number of single family residential units. The larger sites are typically on the outskirts of town and the sites with the highest yield typically have the flattest topography. This has to do with the land it takes to achieve a flat buildable lot. As the site gets hillier, the overall slope of the site must get translated into smaller slopes between flat lots by grading the site. This takes more land per lot to create a series of regularly shaped flat lots the developer requires. If the site contains real hills, rock outcroppings, protected trees, watershed areas or other resources that cannot be disturbed, the development must go around them. The developer looks for sites that have the least of these kinds of issues. The sites with the flattest topography are typically green

Figure 4.10.
Housing Development cut into forest adjacent to Chesapeake Bay

fields, often farmland. The practice of using farmland for subdivisions was even noted by Clarence Perry (the influence behind much of the FHA's ideas for development) in 1939.[26] The larger sites typically are farmland as well. The developer then plans the site, arranging the site to minimize the number of streets, maximize the number of cul-de-sacs, and create the maximum number of house lots.

Original FHA street widths called for a fifty foot right of way with a paved surface that varied between eighteen to twenty four feet dependent on the hierarchy of traffic intensity. The remainder of the right-of way was for sidewalks and street side planted parkways on each side of the paved surface.[27] The FHA went as far as requiring permanent shade street trees of a certain species and spacing along the street along with groupings of shrubs, and strongly encouraged the use of a landscape architect. Today's street design has widened the right of way to sixty feet, with a minimum of thirty four feet of pavement. This system is based on the

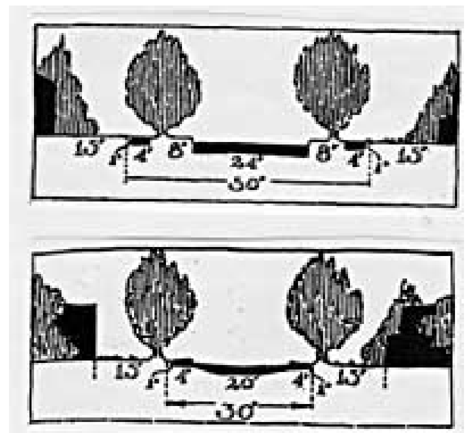
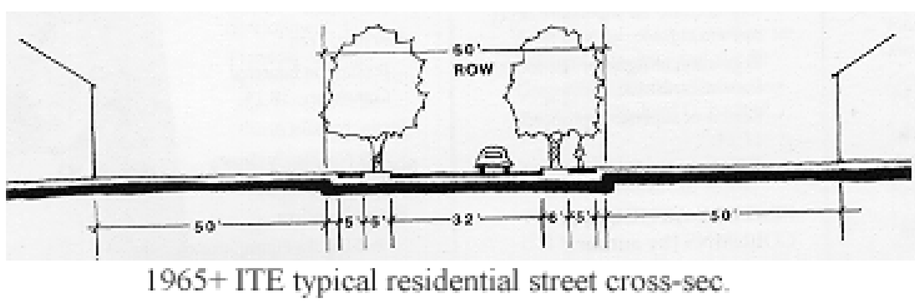


Figure 4.11.
Original FHA street width diagram



Institute of Transportation Engineers (ITE) Recommended Practice for Subdivision Streets. The ITE standards were intended to "provide maximum livability. This requires a safe and efficient access and circulation system, connecting homes, schools, playgrounds, shops and other subdivision

Figure 4.12.
1965 ITE street standards, which remain similar today. Note also the suggested setback distance from street to residences

26. Perry, Housing for the Machine Age.

27. National Register Publications, "Suburban Landscapes: The Federal Housing Administrations's Principles for Neighborhood Planning and the Design of Small Houses."

activities for both pedestrians and vehicles."[28] Although the intention was livability, in practice the rigid standards over time have been interpreted by the engineering community to make the streets wide enough for a fire or trash truck to easily move down them with two driving lanes and parking on both sides. Unfortunately these widened streets promote higher travel speeds. The higher travel speeds in turn increase accident rates and wider streets have not proven to be necessary for emergency vehicles.[29] As engineers develop the site plan, they look back to the FHA guidelines and opportunities to curve the streets to make them more

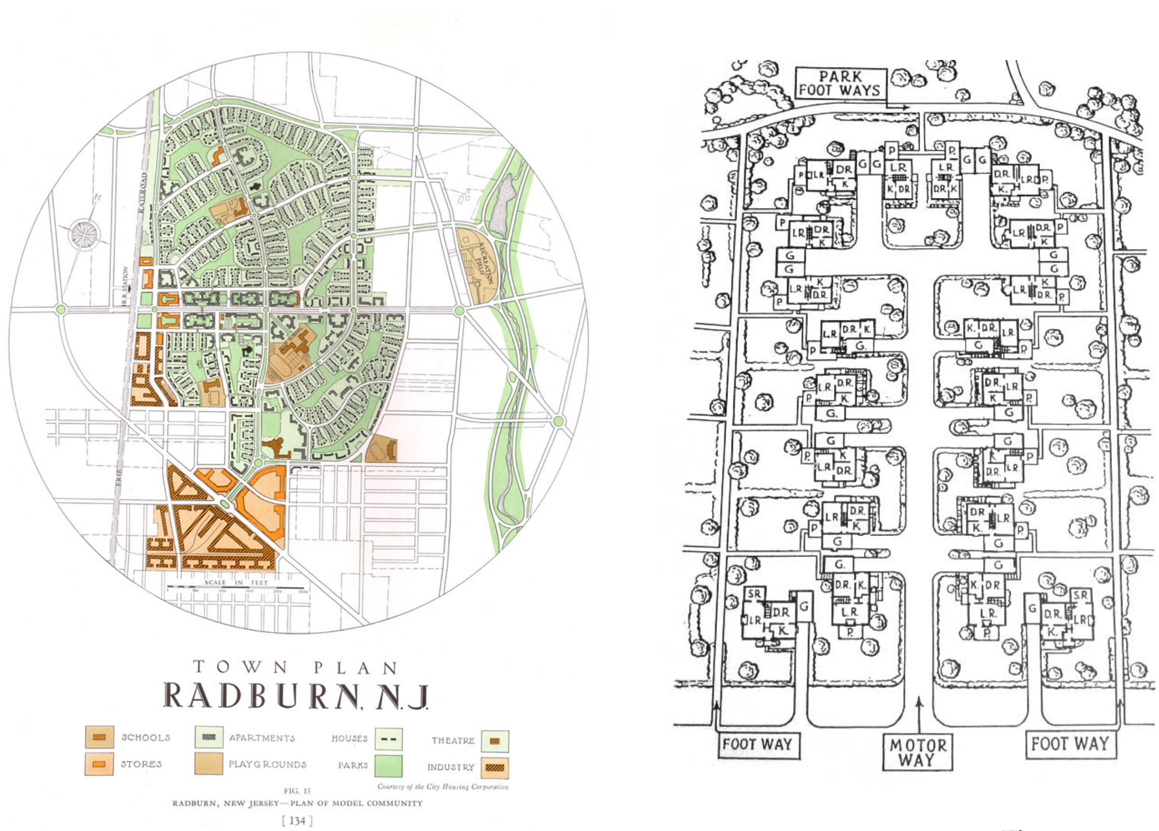


Figure 4.13.
Town Plan and cul-de-sac plan from the town of Radburn, New Jersey

harmonious and picturesque, but then are required to filter those desires with the rigid ITE guidelines. Because of the increased travel speeds, the curves get wider as well.

28. Michael Southworth, and Ben-Joseph, Eran, Streets and the Shaping of Towns and Cities (Washington: Island Press, 2003).

29. Peter Swift, Painter, Dan and Goldstein, Matthew, "Residential Street Typology and Injury Accident Frequency," (Longmont, CO2006).

Suburbia is often defined as the place of cul-de-sacs. The literal translation of cul-de-sac is "bottom of the bag". The birthplace of the cul-de-sac in America is the town of Radburn, New Jersey, designed by Clarence Stein and Henry Wright in 1929 [30]. The main distinction between Radburn and the cul-de-sac of today is that at Radburn, the cul-de-sac was a narrow lane that the garages faced onto, while the front of the house, including the entrance,

Figure 4.14.
View down a cul-de-sac at Radburn. Note the narrow paved area and substantial landscaping.

Figure 4.15.
Aerial view of Radburn cul-de-sac. Note that front of the houses were accessed by walking down through the greenbelt.

was located on the opposite side of the house facing a greenbelt and accessed by a pedestrian foot path. For the

30. Cynthia L. Girling and Kenneth I. Helphand, Yard, Street, Park : The Design of Suburban Open Space (New York: J. Wiley, 1994).

developer following FHA's lead, cul-de-sacs are seen as a way to get more lots into oddly shaped sites. Cul-de-sacs are a desirable amenity in the suburbs, and home buyers pay a premium to purchase a home on one.[31] They are seen as quieter and safer, because there is no through traffic and anyone driving into one is assumed to be a neighbor or a friend. Studies seem to bear this out. Traffic studies show a decrease in accidents in cul-de-sac neighborhoods, crime is less, and residents' perception of street livability is higher.[32]

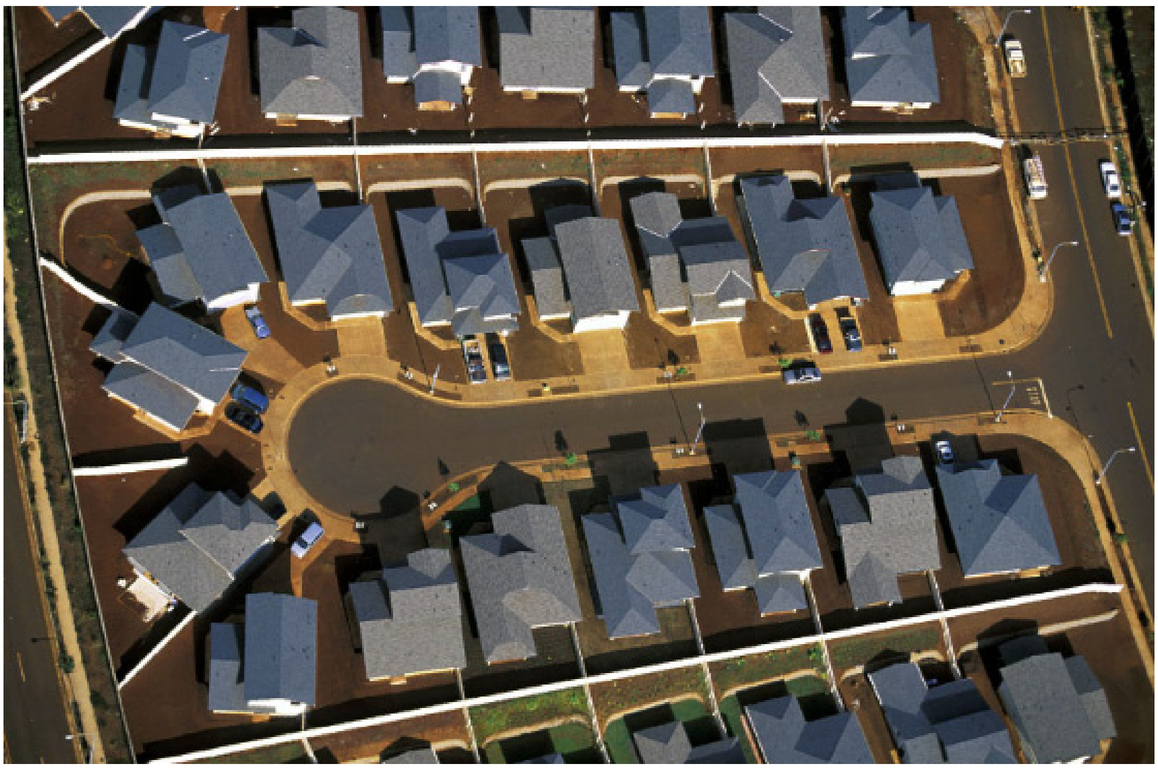


Figure 4.16.
Detail of Cul-de-Sac Subdivision
Honolulu Area, Hawaii
image © Alex MacLean

Critics though point to safety statistics that indicate that cul-de-sacs have some of the highest rates of traffic accidents involving young children.[33] The width of the cul-de-sac is designed for a fire or trash truck to turn around without complicated maneuvering, typically with a radius of 50 feet.[34] Within the original intent of the FHA guidelines, cul-de-sacs were intended to be short, with few houses

31. Amir Efrati, "The Suburbs under Seige," Wall Street Journal 2006.
32. Southworth, Streets and the Shaping of Towns and Cities.
33. John Nielsen, "Cul-De-Sacs: Suburban Dream or Dead End?," in Morning Edition (2006).
34. Southworth, Streets and the Shaping of Towns and Cities.

on them as the topography and site dictated. Today's cul-de-sacs can be up to 1000 feet long by ITE standards.[35]

The size of the lot is typically based on a minimum lot size as determined by the jurisdiction; the most common single family lot size is between 4445 and 8890 square feet (1/8th to 1/4th acre) in area[36] with fifty feet of street frontage. This fifty foot street frontage is not a random number. A wider street frontage, typically desired by the city because it decreases the dominance of the garage on the house elevation, is less desirable to the developer, who has to pave a longer street for each house located on it. A narrower street frontage allows a developer to locate more houses per length of paved street. This narrow frontage creates a garage dominated

Figure 4.17.
the Canyon of Garages effect.

street, (the "canyon of garages" effect) where often the homeowner has to walk down a side yard past their garage to get to the front door of the house. There is no opportunity for "eyes on the street" because no habitable portion of the house can actually see (or be seen from) the street.

35. Ibid.
36. U.S. Bureau of the Census, "American Housing Survey for the United States " (2007).

Upon each lot a number of “setbacks” (areas you cannot build in) determine the actual built area available for a house. The front yard setback can be traced to the picturesque enclave of Riverside in Chicago designed by Frederick Law Olmstead and Calvert Vaux in 1869.[37] Unlike previous developments

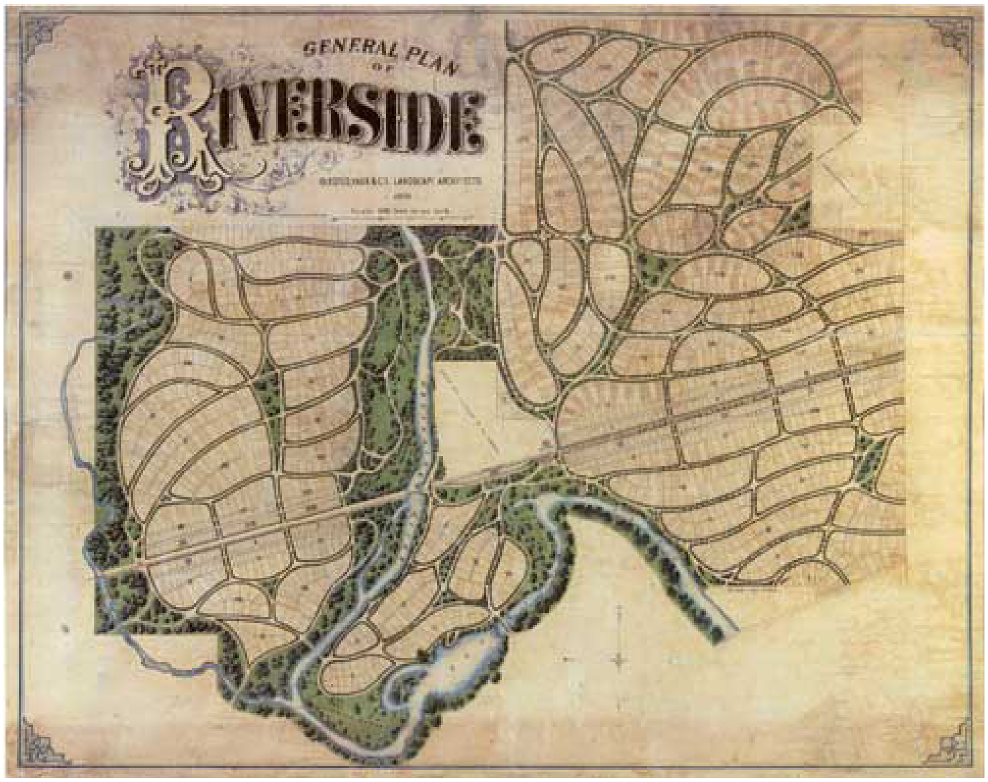


Figure 4.18.
Riverside, Illinois “picturesque enclave” rural subdivision where front yard setbacks were born.

of the day, the lots in Riverside were small at half an acre, and Olmstead was concerned that an owner could potentially build an ugly house, so he mandated that the houses be set back from the street a minimum of thirty feet and that each owner plant trees in this planting strip.[38] Today the typical suburban setback is twenty feet deep for the entire width of the lot, but it is now based on how long a driveway would have to be to park a full size car (a Chevrolet Suburban LT2 is 18.53’ long[39]) on the driveway in front of the house.

37. Hayden, Building Suburbia : Green Fields and Urban Growth, 1820-2000.
38. Ibid.
39. Chevrolet, “Chevrolet Suburban,” http://www.chevrolet.com. accessed March 19, 2009.

Side yard setbacks are typically five feet to property line, determined by the minimum dimension you need to be away from your neighbor's house (ten feet between houses, assuming each house is five feet from a property line) and still have windows.[40] At five feet, these areas are unusable as

Figure 4.19.
sideyard setbacks (note property line where grass stops). Colorado Springs, CO. 1968 image © Robert Adams

living space, and typically end up as the place to put trash cans and other items you don't want to see from inside the house. Rear yards are determined based on whether they are "pool size" (twenty feet deep) or not (fifteen feet deep). Within this setback envelope a garage capable of holding a minimum of two Suburbans side by side within a twenty by twenty foot space is required. Anecdotally, in suburbia these garages are almost always filled with things other than cars, so the cars end up on the driveway leading to the garage in the front setback area. Each lot then, must

40. International Code Council, "2006 International Residential Code for One and Two Family Dwellings," ed. International Code Council (2006).

accommodate 4 cars worth (over 800 square feet) of space. Discounting the garage space from the setback envelope yields an average 2000 square foot "footprint" for a house.

Figure 4.20.
The original Levittown house.

The typical single family suburban house in 1950 was a two bedroom, one bath, one story house of 1000 square feet or less.[41] The typical home today is two story, three or more bedrooms and at least two bathrooms.[42] The size of the average single family detached house sold in the United States in 2007 was 2,587 square feet[43]. While the size of the home was increasing, over the same period the amount of people living in the home did not, and in fact decreased. In 1950, the square footage per person in a single family home was 286. By the year 2000 the number went to 847 square feet per person.[44] Today who lives in this

41. NAHB Research Center, "A Century of Progress, America's Housing 1900-2000," (National Association of Home Builders, 2003).
42. U.S. Bureau of the Census, "American Housing Survey for the United States ".
43. NAHB Research Center, "Median and Average Square Feet of Floor Area in Detached New One-Family Houses Sold by Location," (2008).
44. NAHB, "Housing Facts: Figures and Trends 2003," (Washington, D.C.2003).

three bedroom, two and a half bath, two story 2,587 square foot house? More often than anything else, two people.[45]

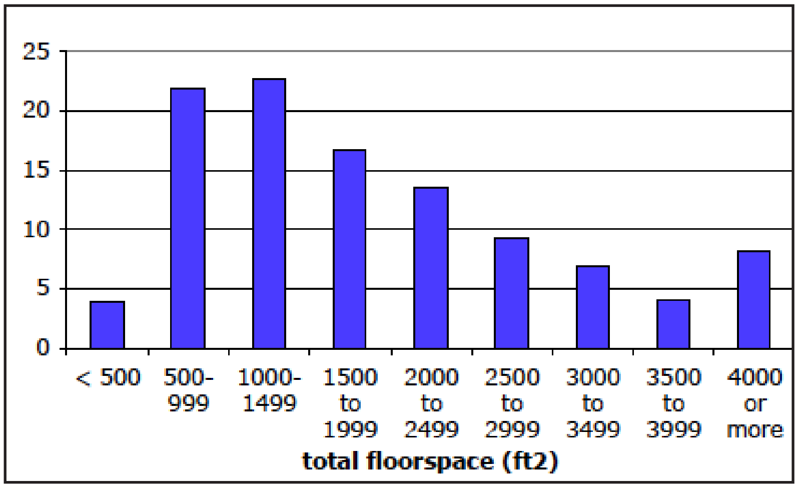


Figure 4.21.
1999 Distribution of U.S. Housing Units by floor area. Source: EIA 2004

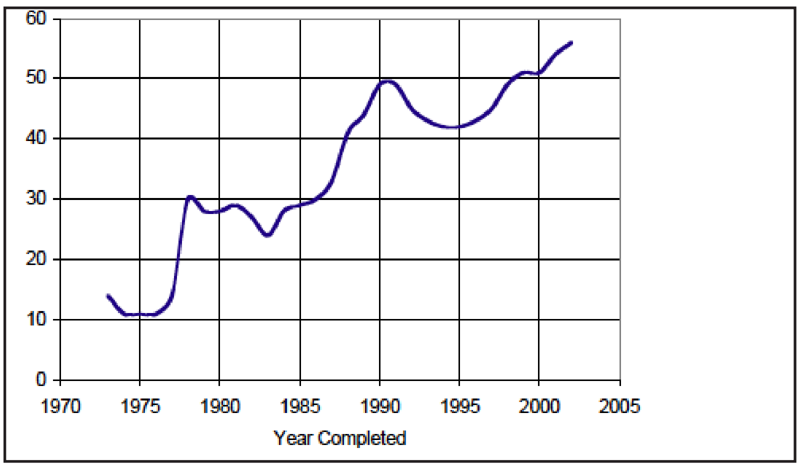


Figure 4.22.
% of single family houses over 2000 sf in the Western Region Source: US Census 2003

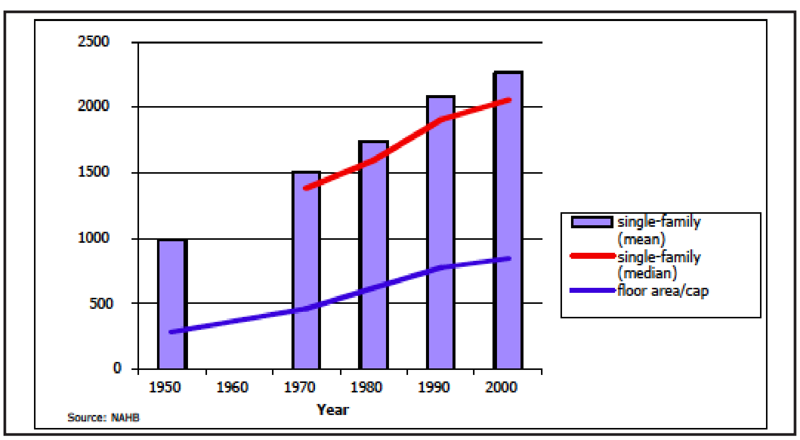


Figure 4.23.
US floor size, mean & median w/ floor area per capita Source: NAHB 2003

45. U.S. Bureau of the Census, "American Housing Survey for the United States "

Sales price for the home is tied primarily to its square footage, and quite often the home size is determined by a number of additional factors. The project itself must get approval from the jurisdiction (city, county or other municipality), and through the public hearing process, from the public itself. In the approval process the developer proposes the number of units they feel are required to maintain a reasonable profit (the yield based on the site price plus development costs). The overall number of units ultimately is determined based on what the jurisdiction and the public feels is "enough" houses, a figure beyond which a project won't be approved. It is very rare that the maximum number of houses the developer's site will yield is approved by a jurisdiction, most often it is less. As an example, a study in Ventura County California indicated that, although each city in the study anticipated growth in their General Plans for the city, the approved projects were between 55 to 79 percent of the planned capacity.[46] [47] The influence of the public on the approval process is very strong. Incumbent homeowners may be the only people that show up at public hearings other than the projects proponents, and those that show up get heard. These homeowners "want to close the door to their habitat and keep intruders out".[48] The environment is often cited as the reason for resistance to a project. But, if change has to occur, the public is interested in seeing larger houses in a given project, believing these larger houses will be more expensive, raising the entire community's property values. In many areas, this is seen as attracting "executives" to live in the neighborhood. They often believe these larger

46. William Fulton, Williamson, Chris, Mallory Kathleen, Jones, Jeff, "Smart Growth in Action: Housing Capacity and Development in Ventura County," (Reason Public Policy Institute, 2001).

47. It should be noted that the study found that the decrease in number of units happened primarily at the application stage of the process, not in the public hearing process. Reductions at the public hearing level only accounted for a 4 percent reduction. It was unclear in the study whether the developer, working with city staff, decreased the number of units applied for based on what was "approvable". A second study by the same authors confirmed that it is often the case that the capacity cannot always be politically sustained.

48. Jon C. Teaford, The American Suburb: The Basics (New York: Routledge, 2008).

houses need to be pushed farther apart, and may require the developer to increase the lot size per house. Many in the public feel that it is environmentally superior to have less homes on a given site, because less houses in the environment is always better than more. In The American Suburb, Jon Teaford writes, "This antihumanity sentiment manifests itself in large-lot zoning and myriad "environmental" initiatives that drive up home prices and raise economic barriers to an invasion of newcomers." "What is important is to preserve the human habitat for existing residents and make sure that the suburban world they invested in…will not change".[49] The public does not seem to make the connection to how much extra land (and with it extra paving, utility runs and other infrastructure) per house this practice creates.

Figure 4.24.
Front elevation architectural Street Scene.

Through the approval process, the houses being proposed are typically presented in a "street scene" format. This is a two dimensional rendered drawing of the front elevation of each model of the house (typically three or four) in one of each of the "salad dressing" (French, Italian and Ranch) elevation styles. The elevations of the houses are designed as flat entities. In the actual house, design elements and materials usually disappear as the materials round the corner of the house to the sides. These drawings do not show the house in relation to the street, or what the house looks like as you would actually see it in real life.

49. Ibid.

Houses are sold by the floor plan much more so (other than cul-de-sac locations) than by the neighborhood.

Jurisdictions are typically required to provide a certain amount of affordable housing units, and most suburban residential projects are required to contribute their share. As the price of these affordable units is fixed to a cost-of-living variable, these units often must be sold for less than it costs to construct them. Often "in-lieu" fees are paid to the jurisdiction instead of building the houses. These fees are then collected from many developers, and then the jurisdiction funds or builds a larger affordable housing project elsewhere. The offset for the cost of constructing the affordable housing or the in-lieu fee are added to the sales price of the balance of the "market rate" housing units proposed by the developer. The developer is compelled to increase the square footage of the home to be able to justify the sales price, which has been increased to offset the affordable housing fees and the loss of the profitable number of overall units. The square footage of the home drives the lot size higher. The publics' requirement to increase house and lot size while reducing the number of houses on the site to make the project approvable pushes it further. This creates the perfect storm of substantially increased land use per housing unit.

Energy Use.

Residences use an enormous amount of energy and energy use continues to increase. The number of BTUs of energy consumed by residences in 2006 was 21 quadrillion units.[50] This represents an increase of 9.6 percent over the year 2000.[51] In the past, the United States has looked to

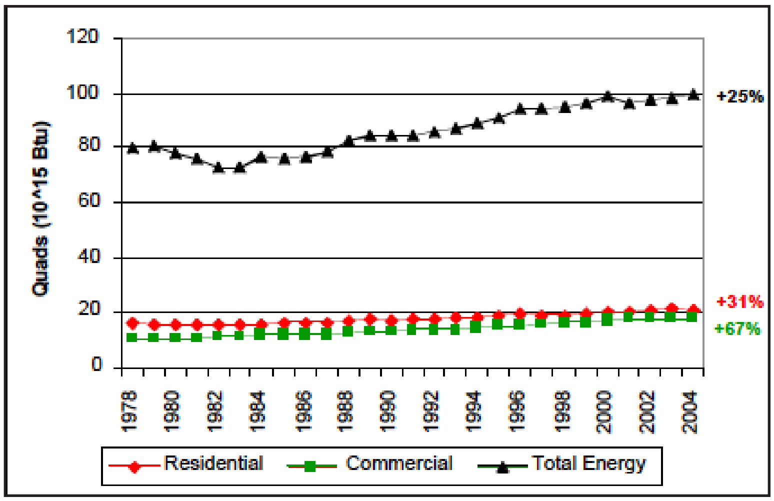


Figure 4.25.
Primary Energy Use in US Buildings 1978-2004
Source: EIA 2004

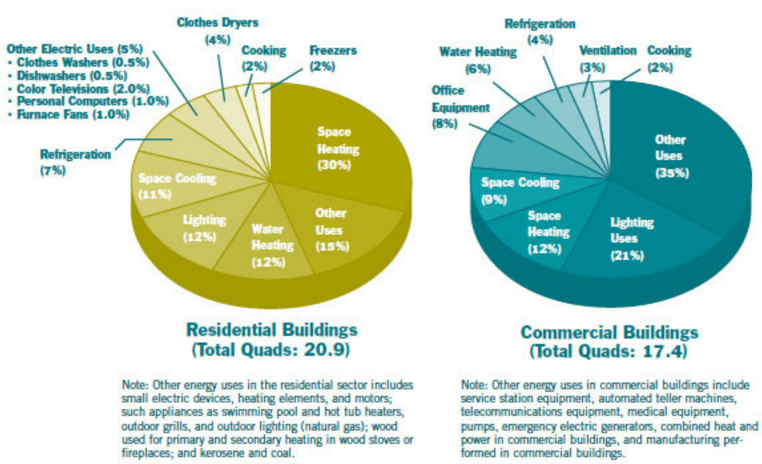


Figure 4.26.
Primary Energy Consumption in Residential and Commercial Buildings 2004.
Source:"Towards a Climate Friendly Built Environment" & EIA 2004

increases in technology to address the issues of an ever increasing demand and an ever diminishing supply of energy. Even with increases in efficiency brought on

50. Reid Ewing, and Rong, Fang, "The Impact of Urban Form on U.S. Residential Energy Use," Housing Policy Debate 19, no. 1 (2008).

51. Marilyn Brown, Logan, Elise, "The Residential Energy and Carbon Footprints of the 100 Largest U.S. Metropolitan Areas," in Working Paper Series (Georgia Tech Ivan Allen School of Public Policy, 2008).

by the new technology, demand has increased more rapidly, so the growth in demand is not sustainable.[52]

Of overall residential energy use, currently nationwide 53 percent of residential household energy use is electricity.[53] Between 2000 and 2005, electrical energy use in residences increase 14.4 percent, from 1,193 million MWh to 1,365 million MWh, faster than the increase in overall residential energy use. This translates to an average of 4.62 MWh of electrical energy for each resident in the United States in 2005. Within this same time period, cooling degree days increased 13.7 percent, which partially explains the increase, in that most air conditioning equipment is powered by electricity.[54]

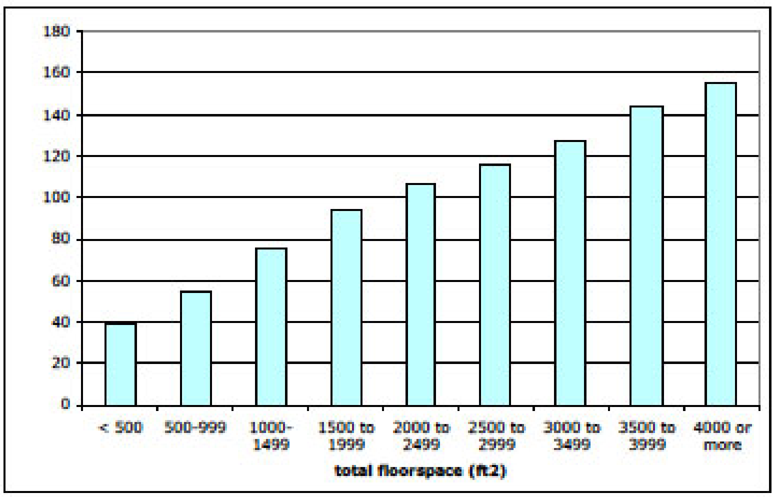


Figure 4.27.
1999 Energy Consumption for houses per household by house size. Source: EIA 2004

The type and size of a residence has an effect on its energy use. Bigger houses use more energy to heat and cool than smaller ones. Bigger houses tend also to have more (and larger) appliances and electrical gadgets (home electronics, pools and spas) with energy demands.[55] [56] Larger homes,

52. Ewing, "The Impact of Urban Form on U.S. Residential Energy Use."
53. Brown, "The Residential Energy and Carbon Footprints of the 100 Largest U.S. Metropolitan Areas."
54. Ibid.
55. Lawrence Berkeley National Laboratory, "Is Efficiency Enough? Towards a New Framework for Carbon Savings in the California Residential Sector," (California Energy Commission, 2005).
56. Harris, "Don't Supersize Me! Toward a Policy of Consumption-Based Energy

since they are more efficient in enclosing space within a surface envelope should be more efficient to heat and cool. In reality it is the opposite, because today's larger homes have complicated exterior envelopes (multiple roof peaks and dormers, bay windows, etc.) adding more exterior surface area and providing more places for air leakage and insufficient insulation.[57] Large houses consume a disproportionate amount of the energy used in residences. In a California study, very large houses (over 4000 square feet) only represented 8 percent of the housing stock, but consumed

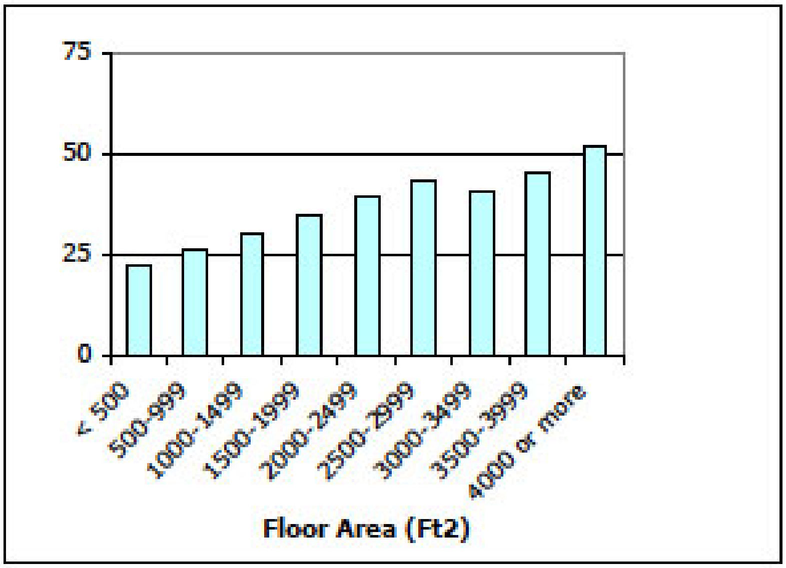


Figure 4.28.
2001 Residential Energy use per household member by house size. Source: EIA 2004

13 percent of the energy.[58] They also found that the larger the house, the more energy used per household member.

Multifamily houses use less energy than single family houses do, primarily because there is less surface area exposed to the outside elements (the internal common walls are only exposed to the conditioned space of the adjacent units).

There are portions of the country where electricity is the sole energy use in residences. For a typical all electrical energy house, the energy use is approximately 12KWh per square

Efficiency."

57. Ibid.

58. Lawrence Berkeley National Laboratory, "Is Efficiency Enough? Towards a New Framework for Carbon Savings in the California Residential Sector."

foot of residence per year.[59] Electricity generation comes mainly from two sources. Coal fired power plants produce the majority of electricity in this country. Historically, coal fired electricity plants operate at about 40 percent efficiency. As this power moves through the distribution and transmission lines and into the typical incandescent light bulb in a home, up to 97 percent of the energy in the coal is lost to waste heat.[60] Electricity generation is estimated to be responsible for 71 percent of carbon emissions for residential buildings.[61] Natural gas is also used in power plants to generate electricity, and accounts for about 18 percent of the electricity produced in the United States.[62]

Natural gas is the most common fuel used as space heating in residential households, with 57.3 million households, representing 51 percent of all space heating energy used.[63] Natural gas is also the most common fuel for residential water heating purposes, with 59.8 million households, representing 53 percent of all water heating energy used.[64] Total residential natural gas use in 2005 amounted to 1.368 trillion cubic feet of natural gas, or approximately 67,000 cubic feet per household. Although natural gas is considered a "cleaner" fuel, it is still a fossil fuel with a finite supply and volatile pricing. Between 2003 and 2007 the price for residential natural gas delivered to the consumer in the United States rose 26 percent.[65]

59. NAHB Research Center, "Review of Residential Electrical Energy Use Data," (Upper Marlboro, MD2001).
60. Brown, "The Residential Energy and Carbon Footprints of the 100 Largest U.S. Metropolitan Areas."
61. Ibid.
62. Ibid.
63. Energy Information Administration, "2005 Residential Energy Consumption Survey," http://www.eia.doe.gov/emeu/recs/recs2005/hc2005_tables/detailed_tables2005.html.
64. Ibid.
65. Energy Information Administration, "Summary Statistics for Natural Gas in the United States, 2003-2007," http://www.eia.doe.gov/pub/oil_gas/natural_gas/data_publications/natural_gas_annual/current/pdf/table_001.pdf.

Water Use.

According to the U.S. Geological Survey, the United States uses 408 billion gallons of water per day, 85 percent is fresh (non saline) water.[66] Building occupants use 12.2 percent of the fresh water, and of that 74.4 percent is residential building occupants.[67] The average household uses 160 gallons of potable water per day per capita.[68] Taken in total households, think of it as a billion glasses of drinking water a day. Of that total 58% or 93 gallons per household is used to water the landscaping. Hot water use is typically around 25 gallons per capita per day with faucet use the largest end use followed by the shower.[69]

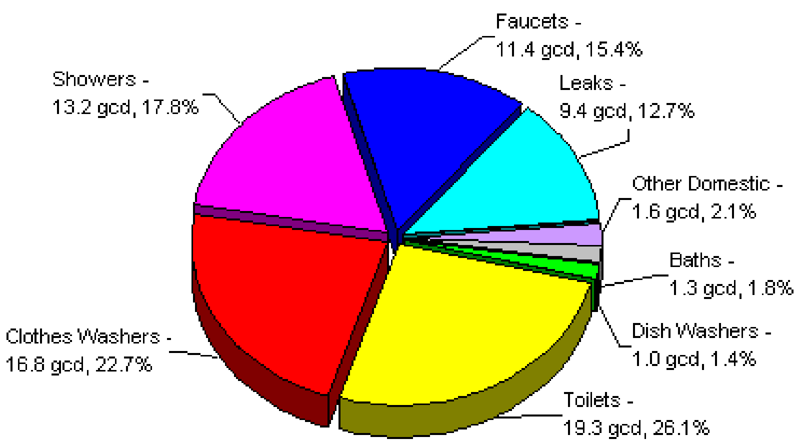


Figure 4.29.
Typical Single Family Home Water Use
Source: AWWA 1998

The public sewer system accepts all waste water generated within the house, no matter the source of the used water, be it sinks, showers, washing machine or toilet, and carries it, always flowing downhill, to a sewer treatment plant.

66. Susan Hutson, et. al.,, "Estimated Use of Water in the United States in 2000," (Denver: U.S. Geological Survey, 2005).

67. USEPA Green Building Workshop, "Buildings and the Environment: A Statistical Summary," ed. USEPA (2004).

68. P.W Mayer, DeOreo, W.B., et.al,, "Residential End Uses of Water," (American Water Works Association Research Foundation, Denver, 1999).

69. William B. DeOreo, Meyer, Peter W.,, "The End Uses of Hot Water in Single Family Homes from Flow Trace Analysis," 2002.

Rainwater that falls on the surface of undeveloped land with vegetation disperses in multiple ways. 40 percent returns to the atmosphere (evapotranspiration), 25 percent is infiltrated into the ground as shallow infiltration, 25 percent is deep infiltration and only 10 percent is runoff.[70] These processes return water to the environment, to moisture in the air for rain, and through infiltration, recharge of underground aquifers. As the amount of impervious surface

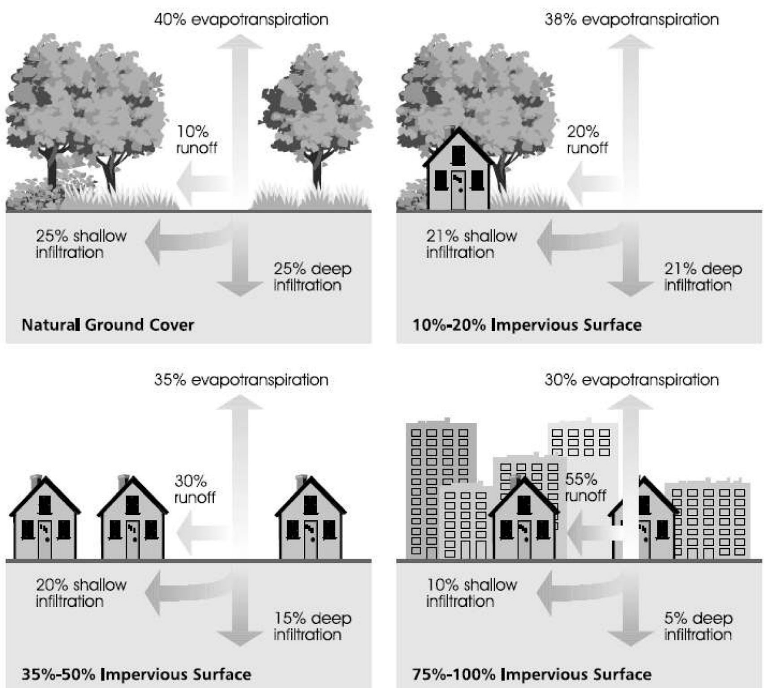


Figure 4.30.
Increase in impervious surface with development
Source: PGCDER 2001

(covered with buildings, driveways, patios sidewalks and roads) increases, the amount of evapotranspiration and infiltration decreases and the amount of runoff increases.

When it rains, a substantial portion of the rainwater that falls on the site lands on impermeable surfaces and then flows off the site into the street and to the storm drain system. In a typical suburban development, with up to 50 percent impervious surface, the amount of runoff increases two hundred percent,[71] keeping that much water

70. PGCDER, "Bioretention Manual," (Prince George's County Maryland2001).
71. Ibid.

from returning to the environment. In typical suburban development, over-watering of the landscaping on site and landscaping water runoff adds additional water to the storm drain system. The water, as it passes over those impervious surfaces picks up any contaminants that were on the surfaces, such as oil, dirt, pesticides, and chemicals. These items then flow through the storm drain system which carries it to local rivers and ultimately to the ocean.

Community.

Community is a term with various meanings to various people. One thing most critics of suburbia agree upon is that suburbia lacks community. Unfortunately, community is a difficult term to quantify. Something that is observable that directly relates to community is connectedness, meaning connectivity between the various components that make community. Connectivity itself has multiple facets, but these facets of connectivity provide the opportunity for a neighborhood to have community. Connectivity in a residential neighborhood begins with a connection between the inside of the house and the outside, then extends from the house to the yard, from the yard to the sidewalk. The sidewalks need to provide an inter connectivity from place to place, from block to block, to amenities and services. The landscape itself needs to connect through these places as well. The houses need to make a connection to the businesses required to support them and provide livelihoods for the homeowners. These neighborhoods need to make a economic connection to the jurisdiction

Figure 4.31.
Small single family home community isolated from others. image © Alex MacLean

in which they are located. And finally, the people within this neighborhood need to be connected emotionally to it.

In a suburban development, the house plan must fit within the building envelope, and each plan type must be able to fit on any lot to maintain flexibility in determining how many of each type of plan they need within a block, based on the desires of the market. By its very nature, each house plan must be able to relate to every lot, and as such,

Figure 4.32.
Garage dominated streets provide no connection from the house to the street.

relates to no lot in particular. The house itself becomes an object on a lot, a volumetric container for the functions that occur there. When these objects are placed next to each other, conflicts occur as private spaces in one house align with public spaces in the next door house. To combat this, openings in the house focus on the rear yard, internalizing the functions of the house and distancing the connection to the outdoors. As it focuses the openings on the rear yard, and the front of the house is dominated by the garage, the opportunity for a connection from the inside of the house to the front yard, sidewalk, and street is eliminated. There is no ability for the private house and its occupants to be part of, or connected to, the public neighborhood.

Figure 4.33.
Colorado Springs, CO 1968
image © Robert Adams

In suburbia, green space is connected, insofar as the front lawns of each house are connected. But these wide setbacks of lawns are private and rarely used as play space. In suburban developments, parks and green space are often put in places leftover from the division of house lots, or only in the areas too challenging topographically to get additional houses. If there are more than one of these spaces, they are rarely if ever connected to each other. The sidewalks adjacent to the front yards reinforce the line between public space and private yard. The sidewalks themselves follow the streets. Because they do, they only go where the streets go, not making any meaningful connections to other blocks or neighborhoods or green space. Because they are adjacent to the long curvilinear street pattern, traveling the same distance a car does makes many destinations too far to walk comfortably, and the sidewalks are rarely used. Because these projects are typically developed on larger sites by different developers, there is a lack of connectivity from one project to the next.

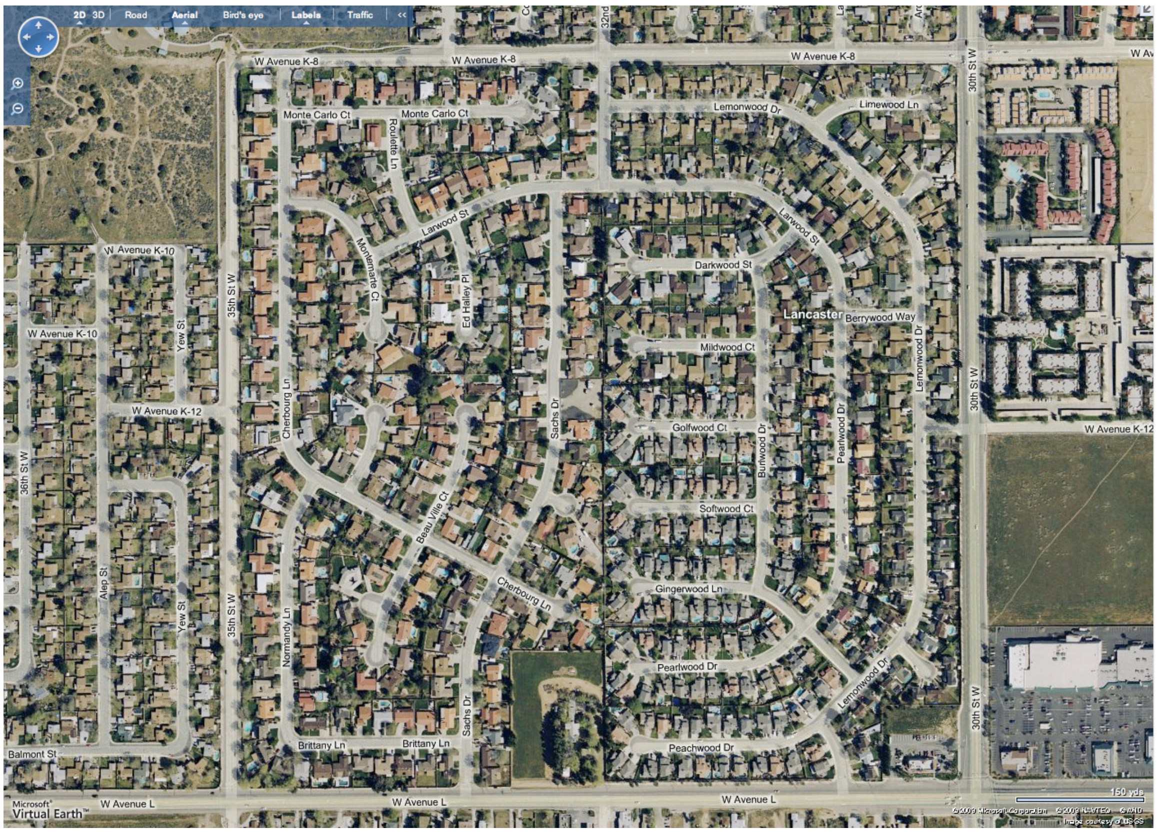


Figure 4.34.
Lack of connectivity between neighborhoods. Lancaster, California

Single family suburban neighborhoods are single use places. Home offices are usually not declared as home based businesses so there is not a business tax base for the city, and property taxes are usually the only revenue to the city from the housing development after the community is built. Many city community-development departments are run solely on developer fees, which requires the encouragement of a steady stream of development. In contrast, hamlets and small towns always had a small commercial component, whether it was a general store, a restaurant or public services such as the post office. From the turn of the twentieth century throughout the Second World War, many large manufacturing companies provided

Figure 4.35.
Vanport, Oregon. Factory town built by Kaiser Steel and Shipbuilding.

housing and services to their employees, and some created company towns such as Pullman Illinois (Pullman Train Car Company), Vanport, Oregon (Kaiser Steel and Shipbuilding), McDonald, Ohio (Carnegie Steel). Some of

Figure 4.36.
Pullman, Illiniois. Factory town built by Pullman Train Car Company.

these towns remain today, even though for the most part the companies that founded them are gone. As was mentioned earlier, most single family zoned areas will not allow businesses or other services to locate within the same area.

Suburban development patterns of cul-de-sacs, high speed wide collector roads, and few sidewalks make for a car-required lifestyle. In this manner, they are connected, but only connected as it serves the convenience of the car. According to Renee Chow in "Suburban Space: The Fabric of Dwelling", "neighborhood is defined by what the individual participants share."[72] In the case of suburbia, the residents of a neighborhood do share many of the same experiences: the driving of their kids to school, the drive to work, the drive home, the drive of the kids everywhere else, the drive to the store, and finally the safety inside of their home. These experiences are for the most part within a container, the inside of a car or the inside of their home (increasingly, this enclosed living is centered around the television, in both the home and the car). As such, there is not that sense of place, of connectivity to the places where we live.

Figure 4.37.
Exurban Development
South Jordan, Utah
image © Alex MacLean

72. Renee Y. Chow, Suburban Space: The Fabric of Dwelling (Berkeley: University of California Press, 2002).

Maintenance of the Status Quo

"The problem is not the profit motive - profit has always been the driver of building in this country - the issue is the pattern. So long as the pattern was the compact, walkable and diverse neighborhood, we could continue growing - and did so for 250 years. When the pattern changed after WWII, it became unsustainable."

Andres Duany

outside Calgary, Alberta Canada

As the research has shown, the typical single family suburban development model has been used to house much of the American population for many years. Suburbs have their own developmental processes and now-mature built form. In "*The American Suburb*" Jon Teaford writes, "American suburbs are not simply peripheral areas with larger lawns and more trees than districts near the historic hub."[1] The development community, jurisdictions, and the mortgage industry are invested in the continuation of the model. The home-buying public is emotionally attached to the dream. As such there are strong reasons to maintain the status quo.

Figure 5.1.
Blue Ash, OH
image © Gordon Bombay

Market response.

Single family home builders believe that they are building what the market wants. Market studies by their builder organizations appear to bear this out. A recent (August 2009) survey by the NAHB indicated that (according to the NAHB press release) only 11 percent of buyers ask about environmentally friendly features. Of those buyers that are

1. Jon C. Teaford, The American Suburb: The Basics (New York: Routledge, 2008).

willing to pay for green features, 57 percent are unlikely to pay more than an additional 2 percent.[2] Another survey of 55+ individuals indicated that only 23 percent are concerned about the environment (although it is not a consideration in their house purchasing decision), 37 percent would want an environmentally friendly home, but only 12 percent would be willing to pay extra (an average of $6,732 if it saved $1000 per year in utility costs) for one. Of the respondents though, 67 percent plan on staying in their current home, and only 12 percent are considering buying a home within the next six years.[3] A recent J.D. Power and Associates study though indicated that of 31 percent of respondents that thought their new home was environmentally friendly, 65 percent said their builders did not identify the green features of their new home.[4] Perhaps if builders themselves let the public know what environmental features they could provide, more people would ask for them. A survey of a broader selection of home builders (from custom home to multifamily) done in 2007 by an outside organization (Green Media) countered that buyers will pay a premium of between 11 and 25 percent for a green-built home. Of interesting note though is the demographics: the average green home buyer in the survey was between 35 and 50, with a college degree and a fair understanding of green products.[5] Perhaps it is more a

Figure 5.2.

Lafayette, IN

2. NAHB, "Home Buyers Want to Save Energy-but Only at the Right Price, NAHB Survey Shows." Note that the survey is not available to the public at this time.

3. MetLife Mature Marketing Institute, "55+ Housing: Builders, Buyers and Beyond," (2009).

4. J.D Power and Associates, "2009 U.S. New-Home Builder Customer Satisfaction Study," (2009).

5. Green Builder Media, "Green Building Practices Survey," (2007).

matter that the survey was conducted of builders about their buyers, or of the questions that get asked within the survey. In a consumer preferences survey (directly with buyers) by NAHB Economics in 2007, the following comes out: 72 percent of respondents say the energy efficient features would influence their purchasing decision, 67 percent say a better insulated home would. 51 percent of respondents would pay an average of $8,964 more up front to save on utility costs, 61 percent would like to have an energy management system, and 91 percent would trade a highly energy efficient home for one less efficient that cost 3 percent less.[6]

One-sided "green" benefits.

Builders see that energy efficient features cost more to install, and if the premise is to comply with the two main energy rating systems, at this time they are right. A sample study by the NAHB indicated that, to achieve a NGBS rating increased building cost from 1.1 percent to 16.9 percent, based on the rating level desired. To achieve ratings under LEED-H takes between 3.6 and 22.9 percent higher building cost to achieve certified through platinum level ratings.[7]

There is a belief with the development community that because the benefit is in lower utility bills and government incentives to the home purchaser, there is no benefit to the developer. A brief overview of the Department of Energy DSIRE website[8] found that the Federal Government has a Energy Efficient

Figure 5.3.
Dallas, TX
image© Michael Rymer

6. NAHB Housing Economics, "2007 Consumer Preference Survey," ed. Gopal Ahluwalia (2008).
7. NAHB Research Center, "Green Home Building Rating Systems-a Sample Comparison," (2008).
8. U.S. DOE, "DSIRE Database of State Incentives for Renewables & Efficiency."

New Homes Tax Credit for Home Builders, which allows for an up to $2000 credit for homes that exceed IECC minimum efficiency standards by 50 percent (roughly equivalent to NGBS Gold or LEED-H Silver). This tax credit is set to expire at the end of this year. There are also state programs, as well as programs offered by the individual utilities. For example, California has an incentive program, the New Solar

Figure 5.4.
Albuquerque, NM
image © Ivan Valiela

Homes Partnership for solar photovoltaic systems only. To qualify for the incentive (payment toward the installed cost of the system, up to $2.50 per watt) the homes must substantially exceed California's already stringent energy efficiency requirements. With the cost of a photovoltaic system averaging $9 per watt for a small system[9], there is still a substantial stumbling block to widespread builder acceptance of this technology. New York provides a direct cash incentive up to $1500 ($3000 for a model home) if the

9. Solarbuzz, "Solar Module Retail Price Environment," Solar Photovoltaic, PV Module, Panel Prices.

home is built to Energy Star standards. Almost every state has local jurisdictions that provide expedited permit processing for energy efficient projects, and many, like Eugene, Oregon have reduced fees.[10] So it appears that there are incentives for builders to provide energy efficient homes, but the energy efficiency requirements to obtain these incentives is typically relatively high compared to a baseline home.

Figure 5.5.
Desert housing image © Alex Mac Lean

Many programs also require a verification period after the occupants move into the home. Since the builder cannot predict the habits of the homeowner, they cannot guarantee that the home will be as efficient as they indicated when applying for the credit. The time, effort, and costs for a builder to participate in these incentive programs could be seen as a disincentive to do so.

Current economic conditions.

Builders want to get building again to return to economic viability. For them to do so, they want to build in the manner they know how. Financing for projects is currently

10. Edward Russo, "Eugene, Or. Offers Incentives, Including Permit Rebates to Help Green Builders," Builder Magazine, September 15 2009.

extremely difficult for builders to obtain.[11] For them to propose anything other than a single family detached housing (such as mixed use or other innovations) is perceived by the lenders as increased risk that they are unwilling to fund. There is a new trend among single family home builders toward smaller houses, but it is to cut costs and make houses more affordable to buyers who are having to deal with pay cuts and furloughs.[12]

Figure 5.6.
Cul-de-sac grading image © Alex Mac Lean

Environment vs. economy.

Many builders and suburban home buyers have conservative viewpoints, and some do not believe the extent of global warming and other environmental issues or at least that they are involved in them as part of the solution. Organizations such as the Heartland Institute agree.[13] In the context of the

11. David Crowe, "The Clampdown, as Banks Continue to Tighten Financing, Builders Feel the Pinch," Builder Magazine, March 9 2009.
12. Alison Rice, "Economic Insight: Keep Homes Small, Affordable," Builder Magazine, August 27 2009.
13. James and Bast Taylor, Joseph, "Environmental Policy and Freedom," http://www.heartland.org/suites/environment/index.html.

current economy, more Americans have decided that they have concerns other than the environment. For the first time since it asked the question in 1984, the Gallup organization found that more Americans (51 percent) said the economy should be given priority over the environment (46 percent).[14] In a study of "green" consumers, the Sheldon Group found similar responses: 59 percent said their top concern is the economy (over the environment), while 73 percent said reducing their energy use is to control their costs (as opposed to lessening their impact on the environment).[15]

Governmental mandates.

Often times a jurisdiction, be it the Federal Government, individual States or a local community will impose restrictions and home features in the form of mandates. The development community will typically lobby against mandates of any kind. Mandates are seen to cost money, which drives home prices higher, making home ownership less affordable. The also see them as providing less flexibility to respond to market and land-use conditions. The development community has an energy research arm, The National Association of Home Builders (NAHB) Research Center and has a history of collaborating with outside organizations such the ICC[16] or the DOE. Through these types of partnerships they have developed their own programs, but most of these are voluntary.

Figure 5.7.
farmland removed for urbanization

14. Gallup, "Americans: Economy Takes Precedence over Environment," (2009).
15. Jennifer Goodman, "Six Myths of Green Consumers," Custom Home, September 8 2009.
16. NAHB: NAHB Applauds ANSI Approval of National Green Building Standard™.

Competition.

Competition among home builders is fierce. Quite often, builders in adjacent communities offer similar houses with similar features and correspondingly similar pricing. Market research would typically justify this practice within a given area. As such, a home builder would be very reluctant to add features that change the price point (or sales price per square foot) of a project if it meant that their product was more expensive in relation to the local competition. Energy efficiency features such as extra insulation or better windows would also typically not be perceived as having a value worth paying extra for. A builder might however, offer an item as an option as opposed to a standard feature. Currently though, an item like photovoltaic panels may add $15,000 to the price of a home, and many home buyers aren't willing to make that commitment. Bob Yoder, Division President of Shea Homes speaking about a project of theirs in San Diego California where photovoltaic panels were offered, said, "it really doesn't work as an option, it doesn't get selected because of the cost."[17] A home builder may though add features that differentiate their product from the local competition if the price remained the same and if market studies warranted it.

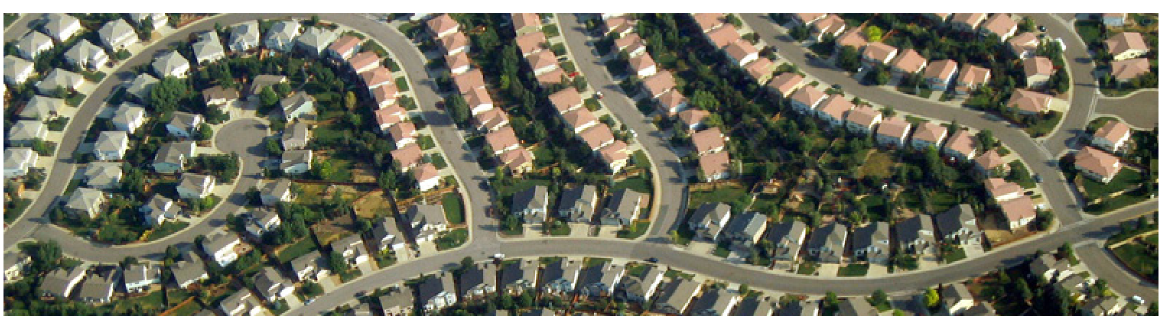


Figure 5.8.
image © Nathan Abels

17. Barbara Hernandez, "Skies to Brighten for Solar?," Los Angeles Times, March 13, 2005.

SUBURBIA TOMORROW

"Make no little plans; they have no magic to stir men's blood and probably themselves will not be realized. Make big plans; aim high in hope and work, remembering that a noble, logical diagram once recorded will never die, but long after we are gone will be a living thing, asserting itself with ever-growing insistency"

Daniel Burnham

New Town at St. Charles, MO

Land Use.

We have seen the origins of suburban development patterns, and the causes of its inefficiencies on the use of land per dwelling unit. It is the intent of this research to alter the drivers of land use efficiency to come up with a new, more efficient model.

If the idea of increasing the density were the only goal in this research, providing a standard multifamily attached housing project would be the obvious answer. Frankly, it would be the easy way out. But as Renee Chow points out, "calls for rejecting single family detached lifestyles confront a culture centuries in the making."[1] The single family house provides light and air from all sides, access to the ground is direct, and homeowners have the autonomy to modify their houses independently of each other.[2] The intention of the research will be to continue to provide single family detached housing as part of an overall project, but do it in such a way as to decrease the amount of land per dwelling.

As land use is driven partially by house size, the size of an individual house will be reduced from the standard average size. With the reduction in house size, providing private outdoor living spaces and

Figure 6.1.
800 square foot house
David Sarti, architect

1. Renee Y. Chow, Suburban Space: The Fabric of Dwelling (Berkeley: University of California Press, 2002).
2. Ibid.

Figure 6.2.
Motor court housing
Horatio Court
Irving Gill 1919

privacy between units will become more critical. Demarcating private space may lead to "attaching" these homes together with privacy walls or other means, but the intent is that these houses live as individual houses.

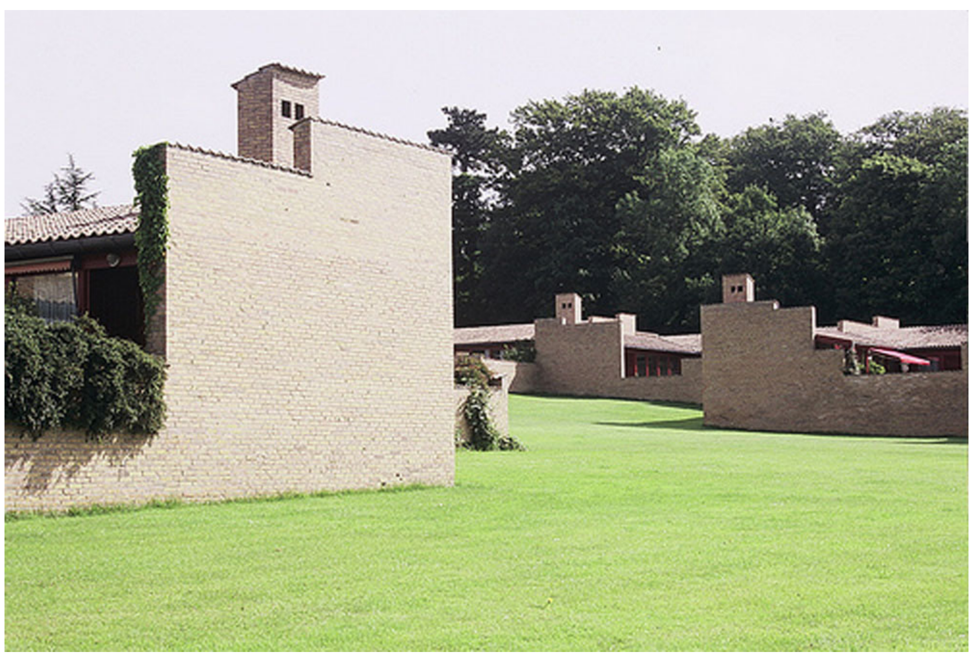


Figure 6.3.
Garden court housing around a common green
Fredensborg Housing
Jorn Utzon 1959

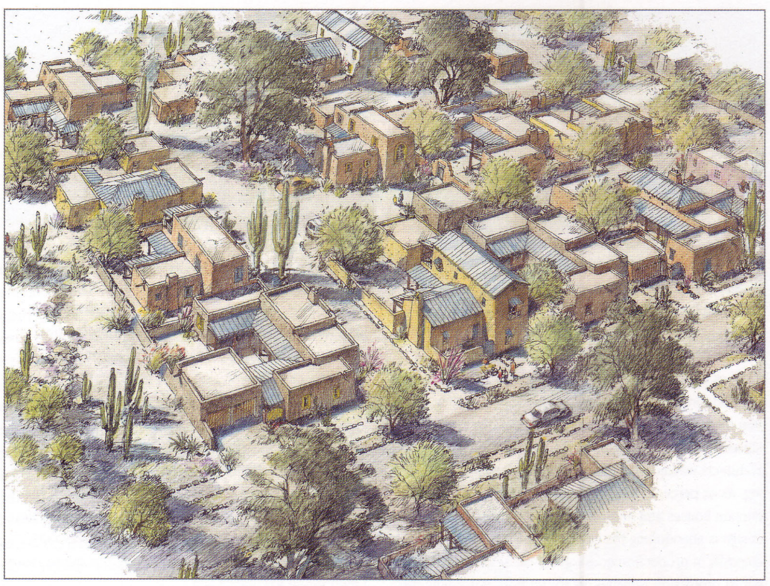


Figure 6.4.
Compound housing
Civano, Arizona
Moule and Polyzoides

In current single family suburban development, each house sits on its own lot, the collection of lots form the block. In order to concentrate on land and energy use, the research will not look at the configuration of individual lots within the block. Once the configuration of buildings were identified and fixed in place, lot lines could be drawn between them. It may provide more flexibility though, to place the entire block within a condominium map, but again, this is not the focus of the research.

In a single family development, there is a very narrow range of house sizes offered to the home buying public, based on factors mentioned earlier and the singular available building development envelope on each identical site. In the design, the building development envelope will be reduced, and multiple options provided. In providing multiple configurations and a smaller envelope, the opportunity for increased density becomes available. It is the intention of the research to provide not only single family residences, but units attached to multi-use business spaces, as well as a mix of attached multifamily apartments. In combination with the provision of multi-use business spaces, the off street parking will be reduced to one or even potentially zero on site. Street parking will be utilized for parking as necessary. The street right-of way will be reduced, and the travel lane width will be altered based on a hierarchy of street uses.

Front yard setbacks will be reduced, and parkways and sidewalk will now be provided within the right of way. Cul-de-sacs will be eliminated within the model, or if there remains a substantive reason to use them, they will be reduced in size, and will maintain pedestrian and bicycle connectivity. Side yard setbacks will be combined to provide for a minimum yard width of ten feet, which will be considered the minimum usable for outdoor living opportunities for yards.

Once a block size is established, it will be the intent to standardize housing configurations within portions of the block, and then have the opportunity to replace these configurations as desired to adapt each block to its setting within a neighborhood. This "plug and play" method will provide for a diversity of housing and building types and provide opportunities for place making within the neighborhood.

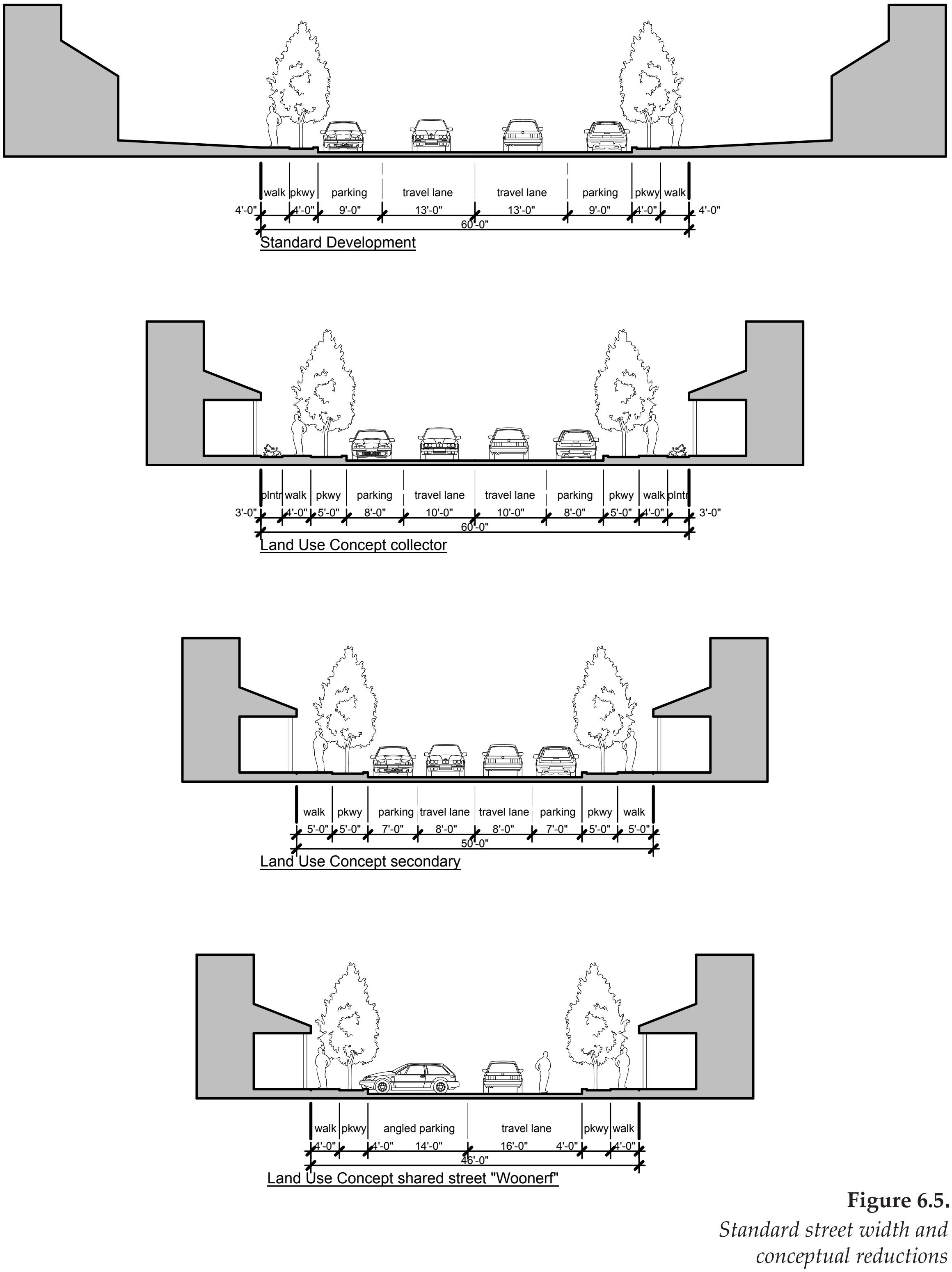


Figure 6.5.
Standard street width and conceptual reductions for land use reduction

Land Use Calculation Methodology.

The intent of this portion of the research was to determine if it was possible to decrease land use per unit by substantially increase the density of a standard suburban block within the same block configuration and size. Other goals were to provide open private space as well as common space, and increase the perviousness of the site for storm water infiltration. To do so required designing a standard suburban lot layout, and a new prototype model within the same site.

Research began by taking an individual standard rectilinear suburban lot of 50 feet by 100 feet as the benchmark. This lot size, although atypical for some parts of the country (especially the rural south), fits within the average lot range (4445 and 8890 square feet, or 1/8th to 1/4th acre)

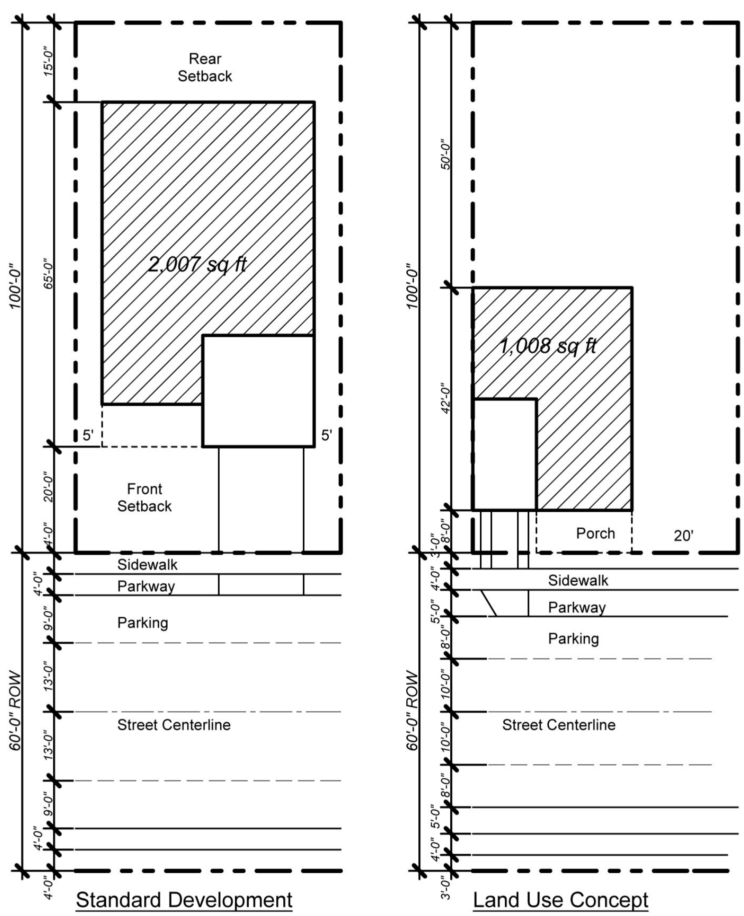


Figure 6.6.
Standard single family home footprint and conceptual reduction in footprint to reduce land use

in area throughout the country[3] and is very common in denser regions of the country (the coasts for example). A fifty foot street frontage is also the norm. Within this typical lot, we located five foot side yard setbacks, a twenty foot front yard setback, and a fifteen foot rear yard setback. These parameters combined dictated the usable “building envelope” that we could place a single family home within. This is the standard of the industry method for locating single family homes within lots.

Within this envelope, we placed a twenty one foot by twenty one foot area for a standard two car garage. The garage was placed in the front corner of the building envelope as would be typical for a “street loaded” garage configuration. The balance of the envelope at the front setback line was reserved for a front entry recession from the garage face. The balance of the building envelope was infilled with building, netting an approximately 2007 square foot house footprint, not counting the garage square footage. This number was considered acceptable, in that the average 2 story house at 2578 square feet,[4] with a first floor of 2007 square feet, would have a second floor of 571 square feet which, within today’s building environment, would allow for up to three bedrooms and two bathrooms on an upper floor, a common arrangement.

This typical lot and house was then multiplied side to side to simulate a typical street, and mirrored end to end to simulate the standard suburban arrangement of lots within a block. At 5000 square feet per lot, eight of these lots yields 40,000 square feet, slightly smaller than an acre in size 43, 560 square feet. Assuming for variations in lot widths based on an actual site, this would net an average density of eight units to the acre. For standardization purposes, we placed two of these acres side by side for a configuration

3. U.S. Bureau of the Census, “American Housing Survey for the United States “ (2007).

4. NAHB, “Median and Average Square Feet of Floor Area in Detached New One-Family Houses Sold by Location,” (Washington, D.C.2008).

of two lots deep by eight lots wide, and assumed streets on both of the long sides, as well as the ends. A standard suburban block would typically be longer, but the intent of the research is to provide a prototypical model that could be adapted for site conditions, one of them being a longer block, but which could be accomplished on a short block.

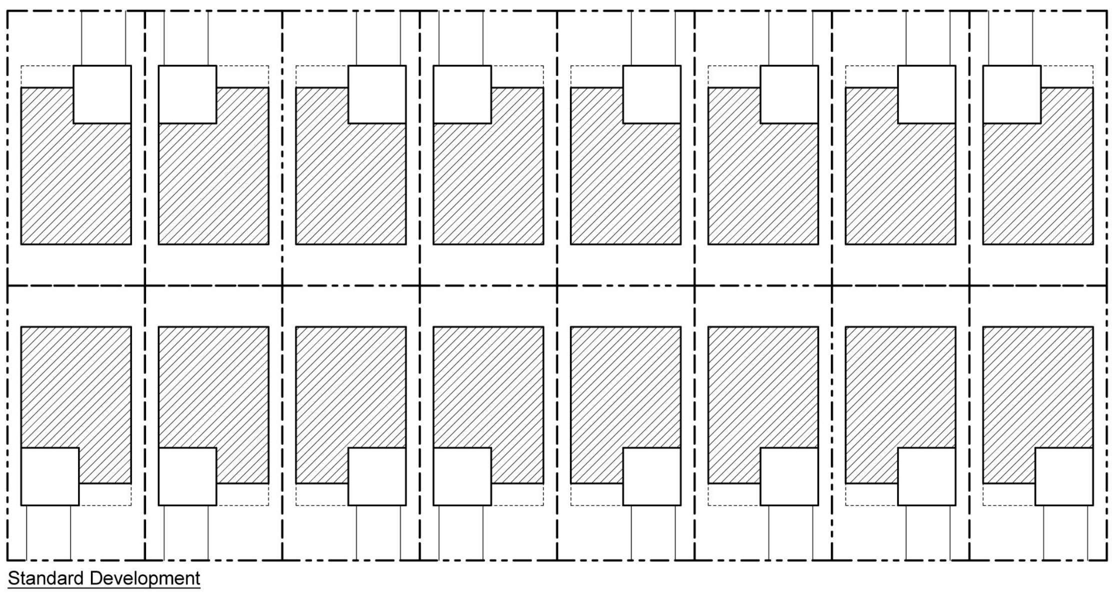


Figure 6.7.

Standard block based on 2 acre (approximate) back to back unit configuration

To design the prototypical block, a new "build-to" line was established ten feet back from the property line. The intention would be to allow porches to occupy this ten foot space between the build-to line and the front property line. New parkway, sidewalks and planters would then occur within the existing street right of way, accounting for reduced traffic lane and parking space widths. The benefit of this build-to line is a more human scaled, pedestrian friendly street width proportion. This built-to line was established on all street frontages, which will allow future flexibility when determining hierarchical street widths to enhance overall community design.

The intent of the research is to determine, through efficiencies in resource use, that a new suburban model is possible. It was not the intent of the research to limit flexibility in housing design or dictate a certain style. As such, the housing was designed relatively generically, and can be open to interpretation as to its arrangement on the site, configuration of interiors and stylistic preferences. There are implications though, that new housing within this model be built as efficiently as possible in terms of materials and space, which should, by its very nature, imply simpler exterior forms. The layout of the block does imply also, that this could be construed as a New Urbanist community. There are certainly lessons to be learned and applied from New Urbanist principles, such as the build-to line and street and building form proportions. This research does not, however imply that the stylistic predisposition for historicist buildings need be applied here. The intent is efficiency, whether cloaked in modern form, historicist models, or developer's clothing.

Figure 6.8.
Modern, New Urbanist, and Developer small housing

To provide for a variety of housing, multiple options were designed. The intent was to provide for single family residences in multiple configurations, as well as apartments and multi-use living that included work and living spaces. As an initial design decision, based on the ability to potentially walk to services, and the notion that most garages today are filled with possessions, all provided garages are single car. Another related decision was to maintain the standard "street loaded" garage condition as opposed to creating new rights-of-way for rear loaded alleys. The garages are set at the build to line, assuming the porches forward of them will prevent them from dominating the streetscape.

Within the single family house type, three houses were designed. Two of the units were designed within a motor-court arrangement. The first is a small, single story one

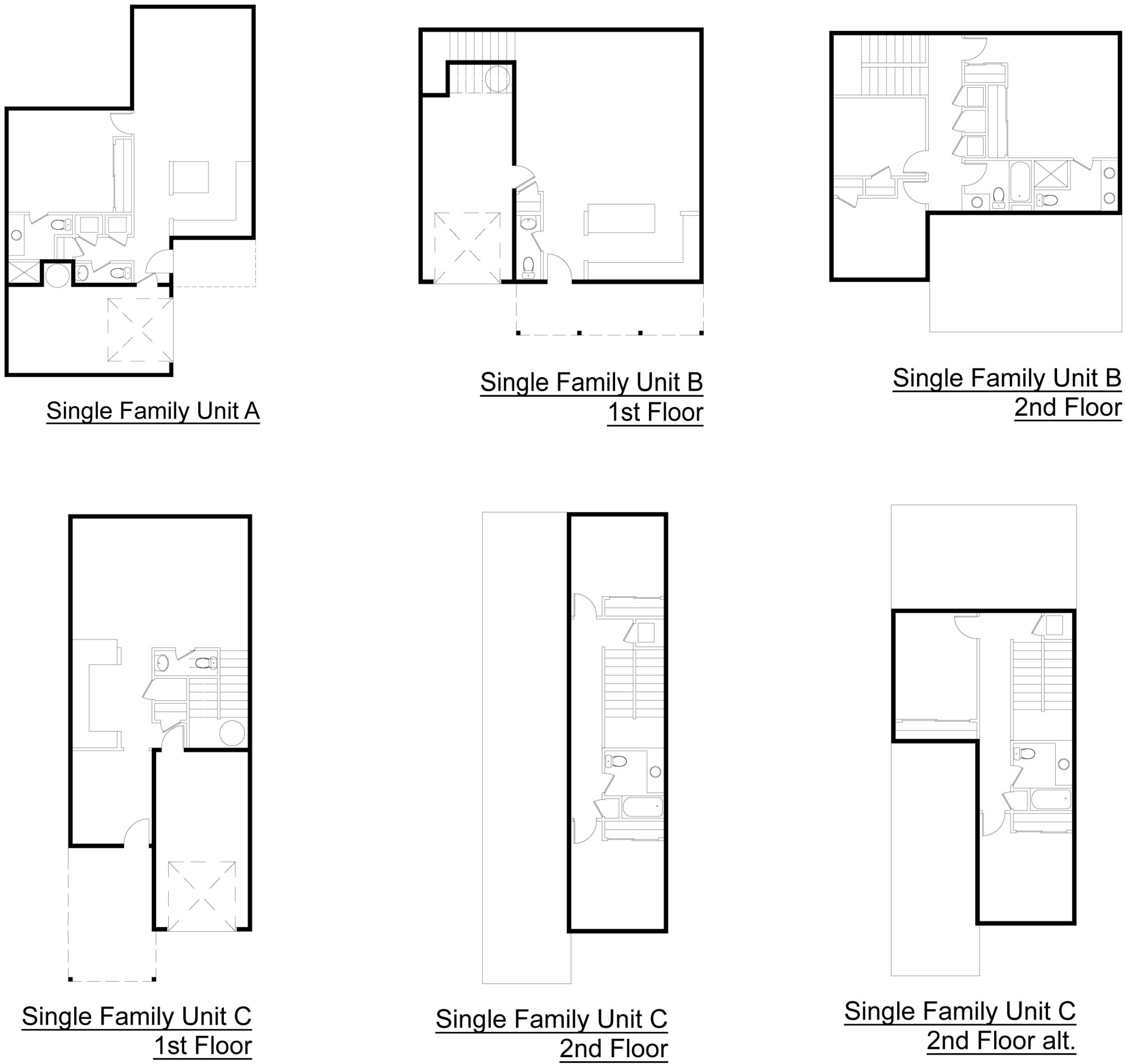


Figure 6.9.
Single Family Unit floor plans

bedroom unit. The second a two story, three bedroom two bath home. The second story of this home looks over the single story home to the common open space to the rear. The arrangement of each of these units provides privacy as well as outdoor private yard space. The third house is a two story two bedroom home with a flex space. This home utilizes a wide side yard for outdoor private living space, as well as access to the common open space. For each of the homes, the private yard space was layed out, using a minimum depth of ten feet of yard.

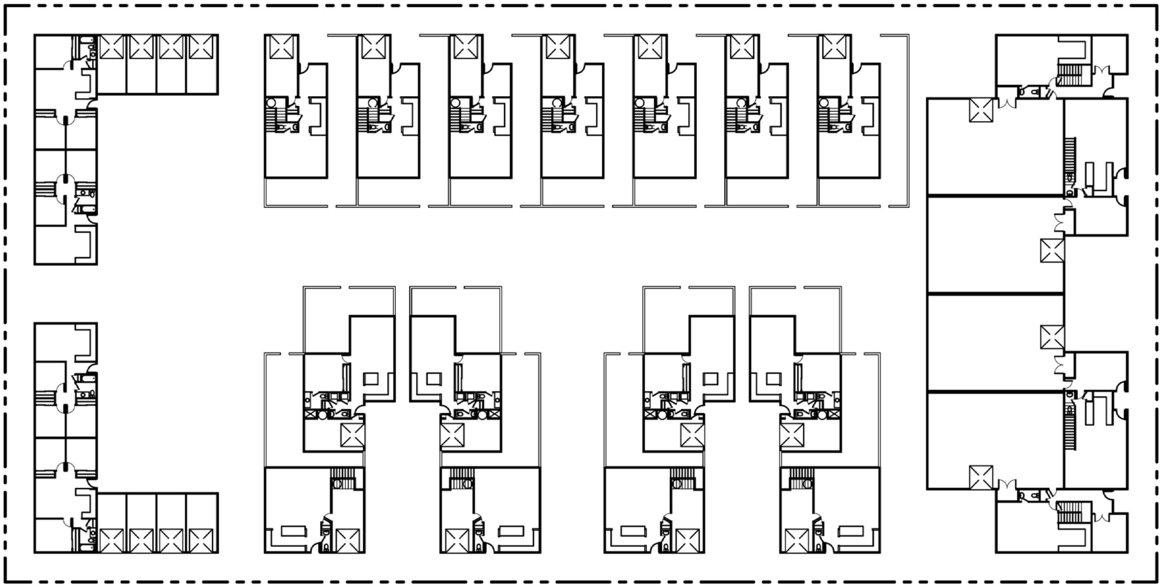


Figure 6.10.
Efficiency block prototype

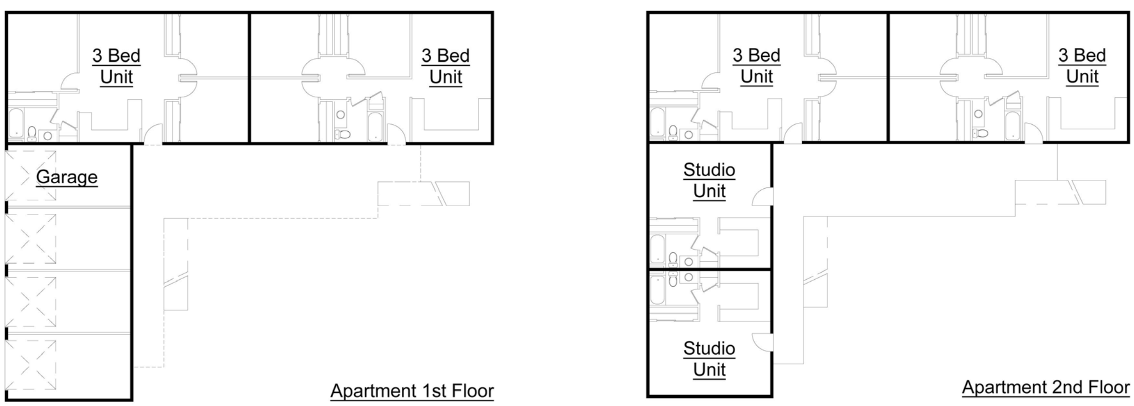


Figure 6.11.
Apartment floor plans.

Within the apartment housing type, two units were designed, a three bedroom unit and a studio apartment. To provide for opportunities for businesses within the block, multi-use apartments were created in two configurations, both with downstairs living space, an office and a large high-ceilinged work space. The upstairs in both configurations is three bedrooms and two bathrooms. Although not shown on the prototypical block plan, an additional building type was designed, with street level storefront, office space above, and apartments for the business owners facing the common space. To calculate yard use, different types of space were

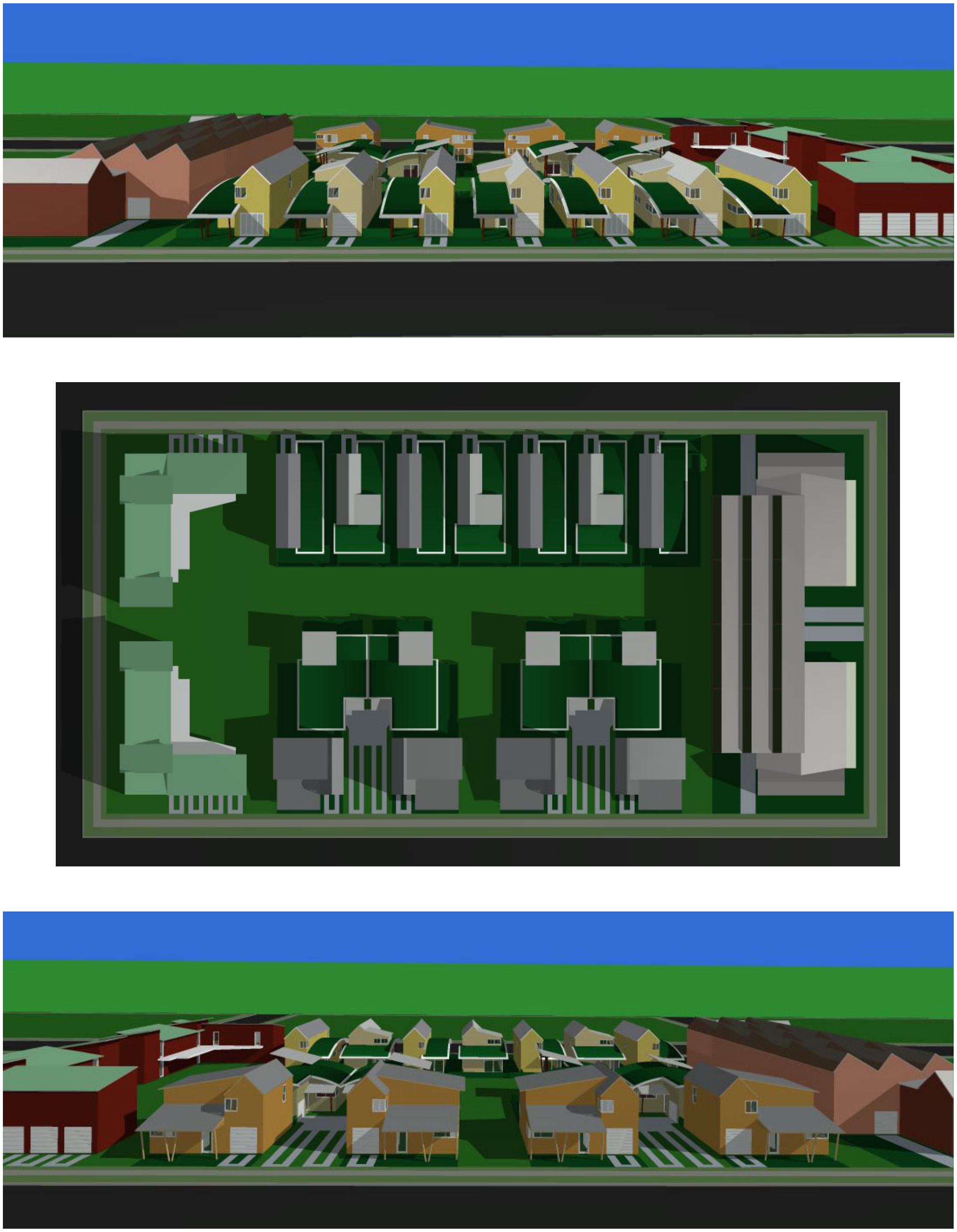


Figure 6.12.
Images of Block model

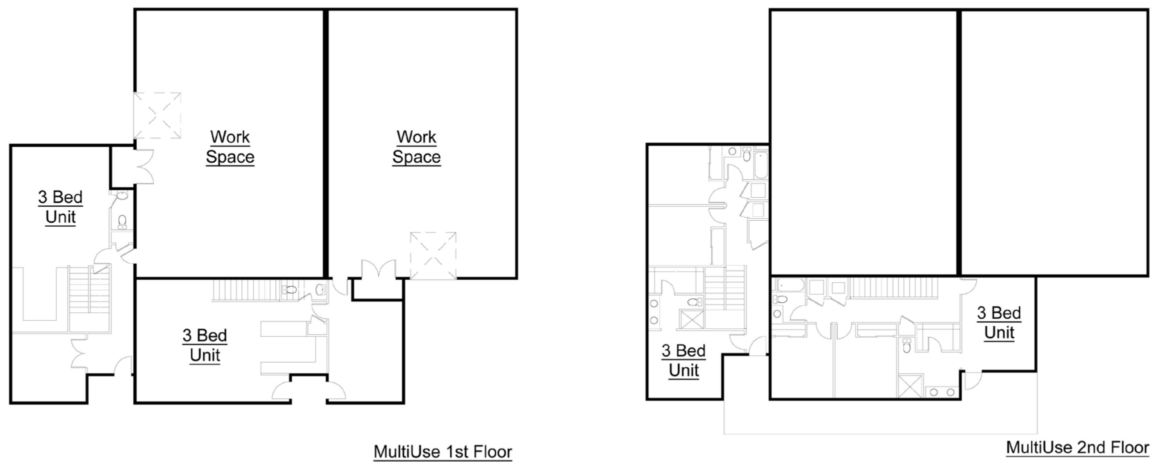


Figure 6.13.
Multiuse floor plans.

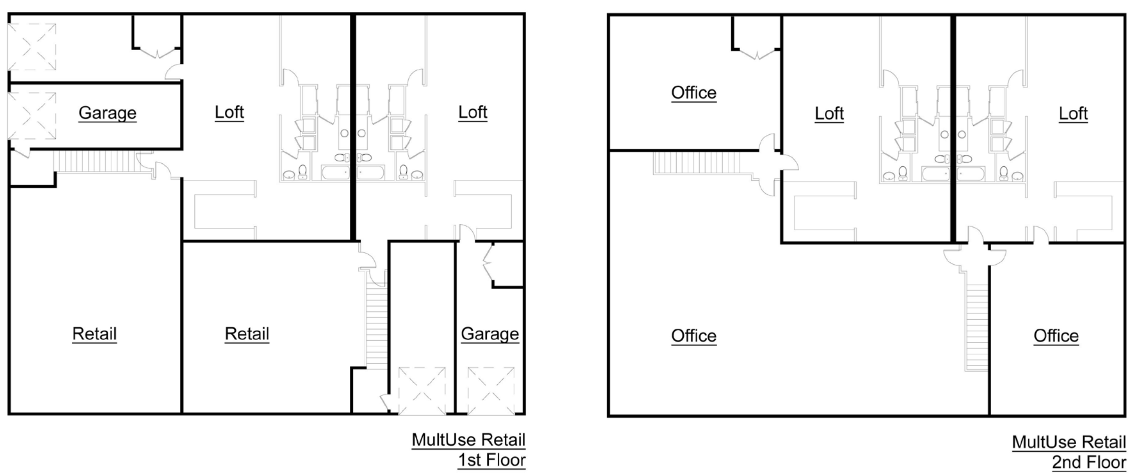


Figure 6.14.
Storefront multiuse apartment floor plans

calculated, livable private space, unlivable private space, and livable public space. For the both blocks, livable yard space was counted as a minimum of ten feet in depth, and spaces that could potentially have porches were included within the calculation if they met the depth requirement. For the standard block, both front and rear yards were counted as livable private space. For the prototypical plan, livable yard space included front yards and the private spaces created for each unit only. Space that met the livability requirement for public space was counted separately.

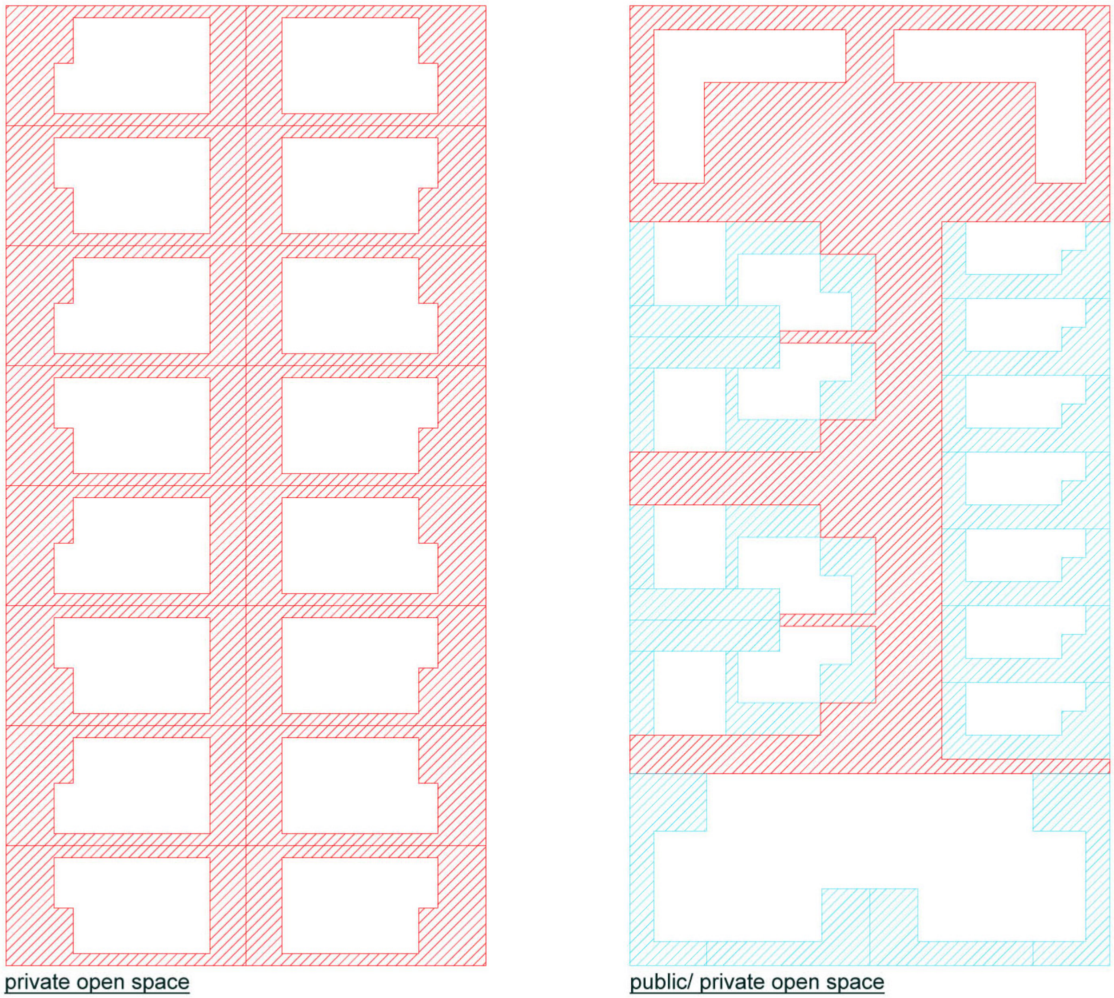


Figure 6.15.
Open Space for the Standard and Prototype blocks

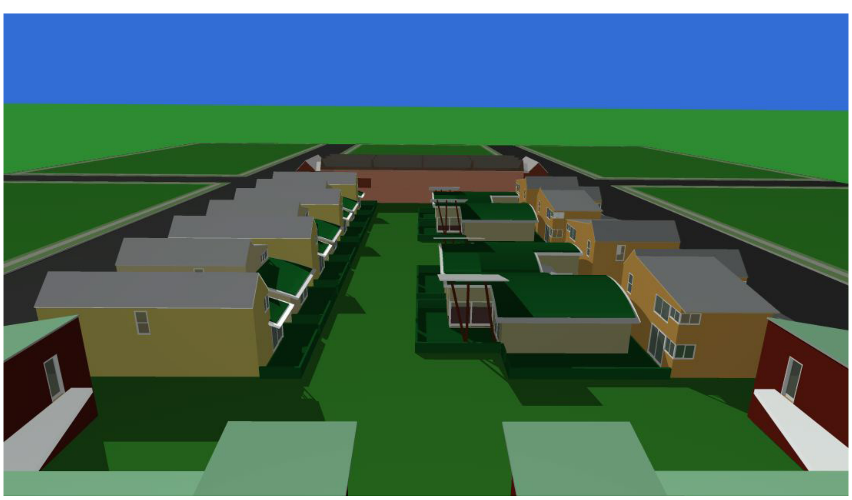


Figure 6.16.
Model showing private and public open space

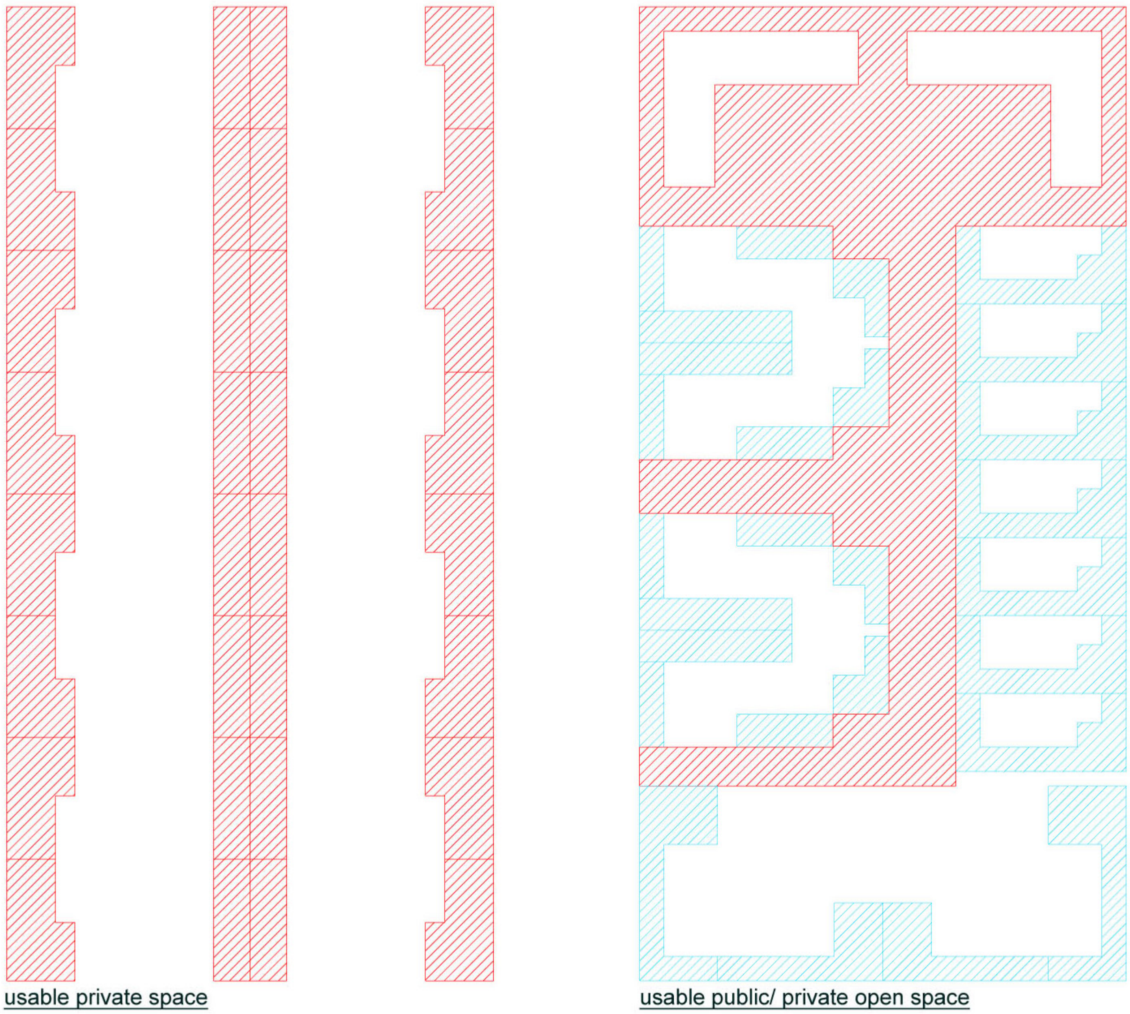


Figure 6.17.
Livable Open Space for the Standard and Prototype blocks

As expected, the standard single family home provided the largest amount of private livable space per house. Of note, of that livable space 63 percent is the front yard, and as indicated elsewhere in this research, the front yard typically includes cars in the driveway and is rarely used. At the block level, private livable space within the standard block accounted for 87 percent of the open space, the balance 13 percent was non livable space, the side yard setbacks. On the prototypical plan only 47 percent of the open space was private livable, but 50 percent of the open space was public livable open space. Only three percent of the total open space was non livable.

Open Space							
	standard	efficiency			standard	efficiency	
total land	80,000	80,000		open space	35712	48339	
pervious	35712	48339		public livable	0	24178	
impervious	44288	31661		private livable	31072	22908	
pervious %	44.64%	60.42%		non livable	4,640	1,253	
	standard	Unit A	Unit B	Unit C	Multi / apt	Multi / apt 2	
private	2552	1340	991	1240	1548	1120	
private livable	1942	1340	883	1240	1548	1120	
private non livable	610	0	108	0	0	0	
number of units	16	4	4	7	2	2	
livable per unit type	31072	5360	3532	8680	3096	2240	

Figure 6.18.
Open Space Calculations

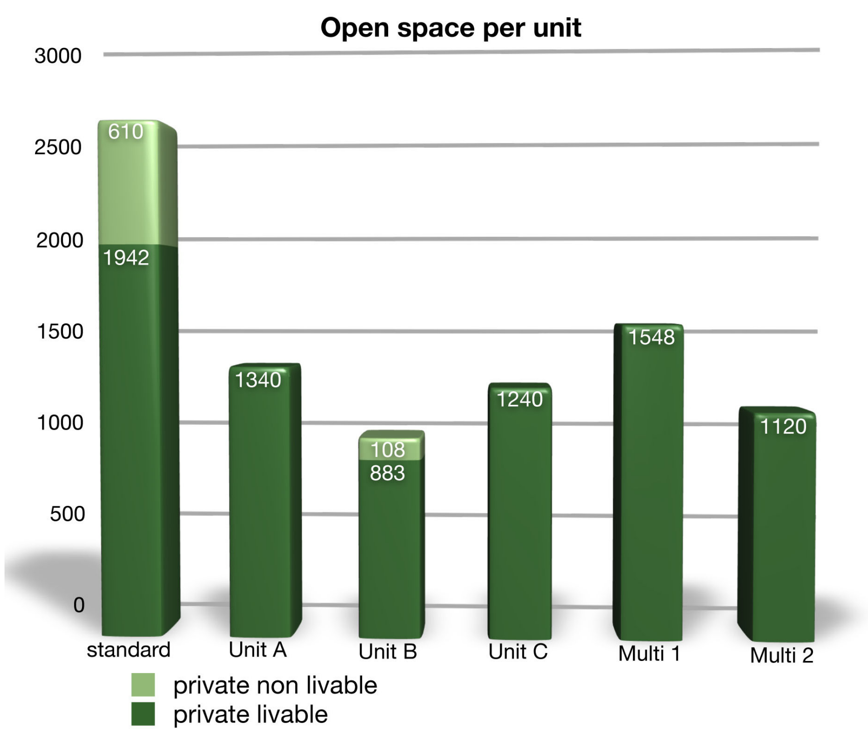


Figure 6.19.
Open Space per Unit

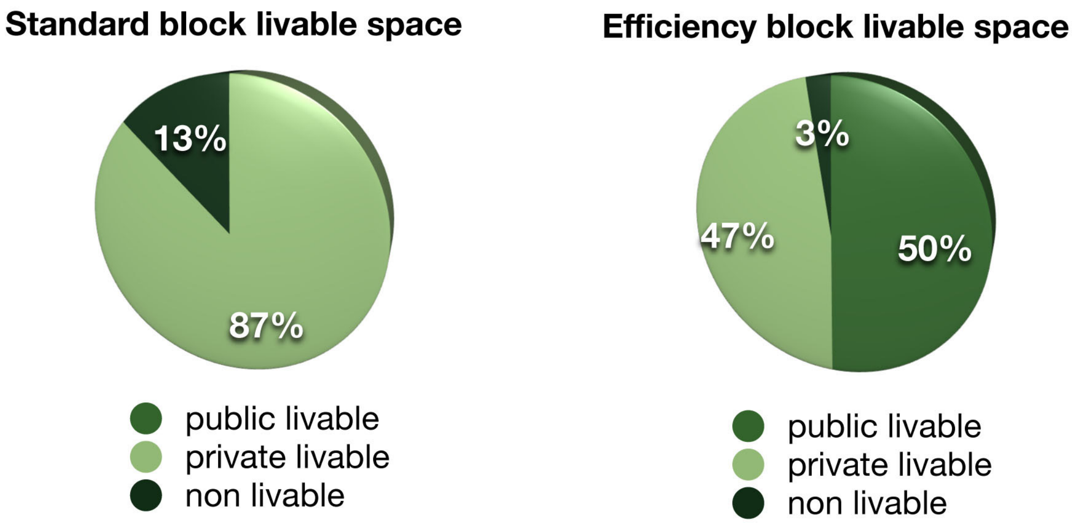


Figure 6.20.
Livable Open Space per Block

All of the building types were designed as modules that would fit in multiple places within the block. This would facilitate the ability to use town planning principles to concentrate business uses within a new "urban core" in the community, lessening the intensity to the edges to single-family only blocks at the perimeter. This allows the five-minute-walk concept to apply within the community as well.

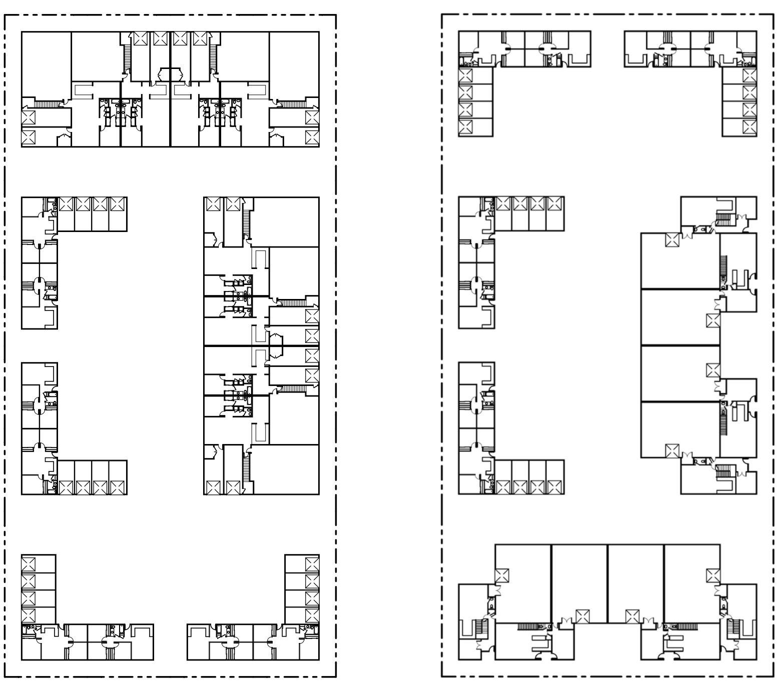


Figure 6.21.
Site options: Storefront Business (left) Multiuse and Apartments (right)

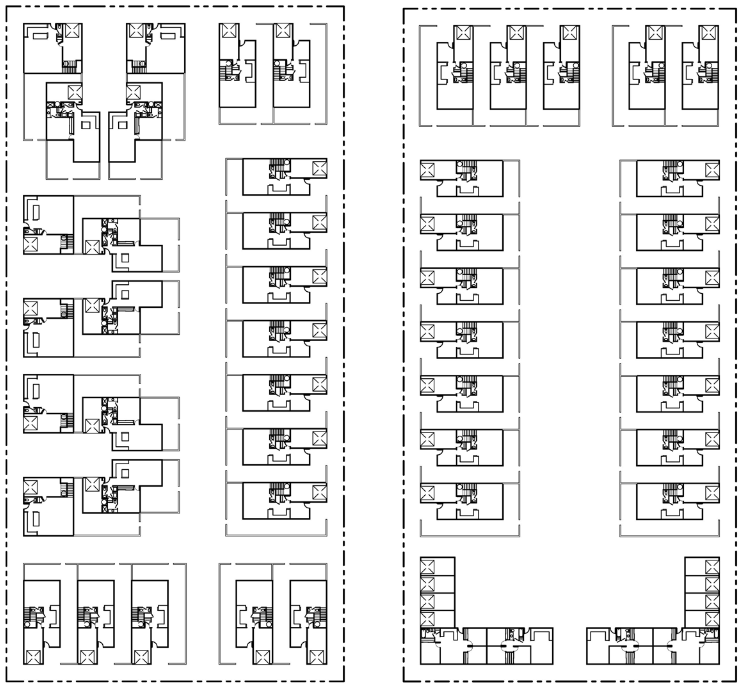


Figure 6.22.
Site options:
Single Family Only (left)
Single Family and Apartments(right)

Ultimately, within the prototype block, the research determined that, within the same land area that housed 16 single family residences, the new prototype provided 15 single family residences, 8 apartments and 4 multi-use units with residence and workspace. Although private open space was reduced per unit, public opens space was provided and pervious surfaces were increased.

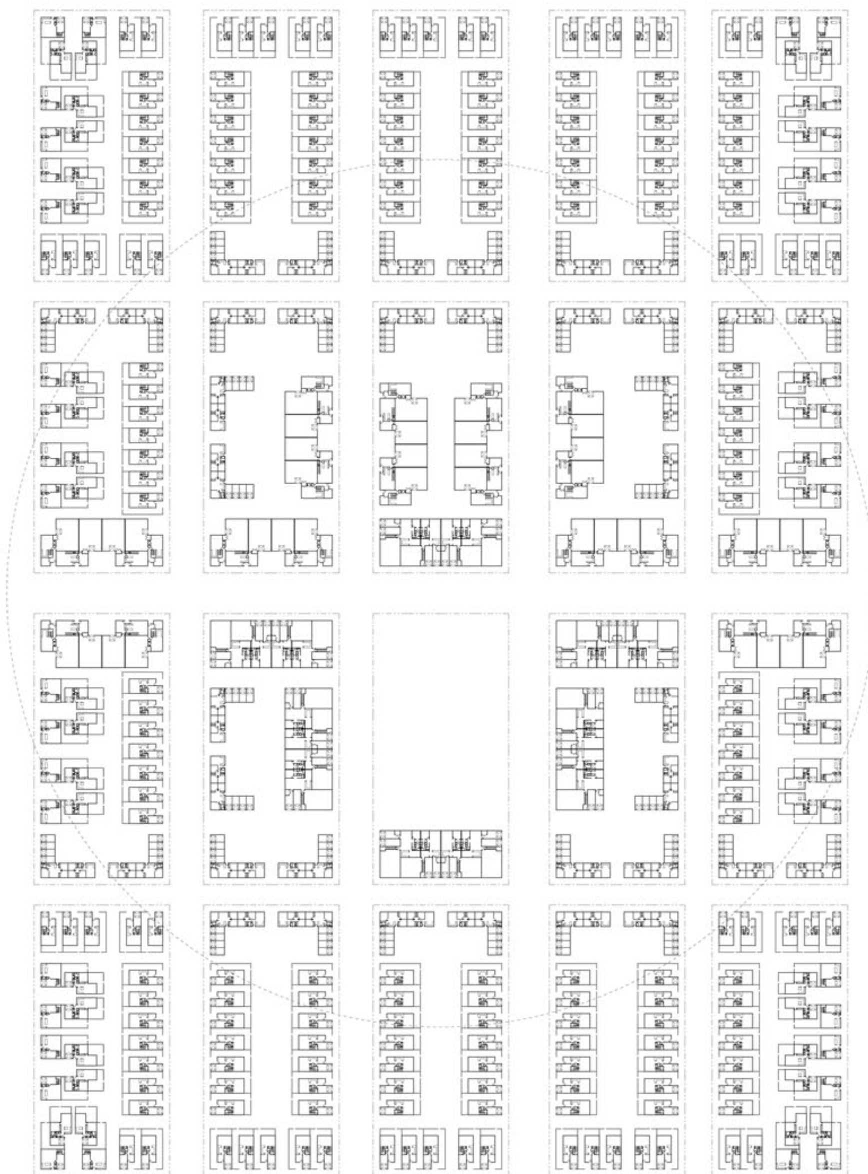


Figure 6.23.
Multiple Prototype Blocks placed in a conceptual community layout

Energy Use.

The goal of the design research will be to provide a Net Zero source energy suburban block. To understand what this means, the options for Net Zero are the following: Net Zero Source Energy Use: Source Energy is the primary energy used to generate (such as through a hydroelectric plant) and deliver energy to a site. A Net Zero Source Energy Building produces at least as much energy as it uses. This is measured over the course of a year, at the source that supplies the energy, most often an electrical utility. Source energy is calculated by multiplying the imported and exported energy by a conversion factor. The conversion factor is based on site-to-source energy usage; the energy used getting the energy to the site. Net Zero Site Energy Use: Similar to a Net Zero Source Energy Building, a Net Zero Site Energy Building produces at least as much energy as it uses. The difference is that the energy use is measured at the site, not at the utility (source). Net Zero Energy Emissions: A Net Zero Energy Emissions Building produces at least as much emissions-free energy as it uses from emissions-free energy sources. Here the difference is that both the energy produced off site (source energy) and site energy are produced from emissions-free (such as wind turbine or solar) renewable sources. Off the Grid: Off the grid refers to a building that is actually not connected to municipal power sources or utilities (the grid). To achieve this, the building must generate all of the energy it uses on site, as well as supply its own water (through a well usually) and take care of its own waste through a private sewage system.

Figure 6.24.
Net Zero Site Energy House
Charlotte , VT
Pill Maharam Architects

An initial concept was to approach the research with a single energy source. The primary sources of energy used in single family residences are electricity and natural gas.[5] Calculating energy use with both electricity and natural gas within the same house would prove difficult within the context and time frame of this research as it relates to efficiencies in energy use. It was determined that the focus would be on an all-electric house, where the net zero goal was measurable and the elimination of the gas utility entirely was potentially possible.

Figure 6.25.
Net Zero Workforce Housing Lopez Island, WA Mithun Architects

When considering a net zero goal, building efficiency plays a significant part of the integrated strategy toward achieving that goal. In considering building efficiency, the following elements should all be researched for an integrated strategy: building size should be reduced to accurately fit the program, the building should have and efficient envelope shape, air infiltration, high performance insulation, high performance glazing, solar orientation and shading, energy efficient lighting, with day lighting and occupancy sensors and high performance mechanical systems including AC and water heat.[6] In talking about building efficiency and being "green", the architect Brian McKay Lyons talks about our fascination with the "gadgets" of energy use: "80% of the green thinking is passive, and

5. Energy Information Administration EIA, "2005 Residential Energy Consumption Survey," http://www.eia.doe.gov/emeu/recs/recs2005/hc2005_tables/detailed_tables2005.html.

6. Marilyn Brown, Frank Southworth, Therese Stovall, "Toward a Climate-Friendly Built Environment," (Pew Center on Global Climate Change, 2005).

it is what the farmer knew, and it cost 20% of the money. The gadgets cost 80% of the money and give you 20% of the value".[7] Architect Peter Pfeiffer FAIA agrees, "You have got to look at the building as a system, and not waste time chasing these silver bullets that don't have the pay backs they're supposed to".[8] McKay Lyons simplifies the process to look at what he refers to as a start-from-zero project: make the building the minimum size necessary, with the minimum impact to the environment, for the minimum budget.[9]

The United States Department of Energy, through its Building Technologies Program has a research program known as Build America. This program combines DOE researchers with the home building industry to produce higher efficiency residential buildings. The goal is to create commercially viable zero energy homes by 2020. Under the standard Build America benchmark system, which takes a typical builder's standard home and then adds incremental efficiencies such as improved wall insulation, higher performance windows, and fluorescent lighting, reduces energy consumption by at least 15 percent. Adding solar water heat and photovoltaic panels increases the energy savings to 72 percent.[10] In a single study with Habitat for Humanity, a grid-tied affordable home was built that actually created a 12 percent surplus in electrical energy using off-the-shelf parts

Figure 6.26.
Build America/ Habitat for Humanity Zero Net Energy House.

7. Tad Fettig, "Village Architect," in e squared: the Economies of being Environmentally Conscious, ed. Tad Fettig (2008).
8. Bruce Snider, "Mainstream Green: Architect Peter Pfeiffer Makes a Case for the Everyday Sustainable Home," Custom Home, no. July-August 2005 (2005).
9. Fettig, "Village Architect."
10. Robert Hendron, "Building America Research Benchmark Definition, Updated December 29, 2004," (Build America, U.S. Department of Energy, 2004).

and standard construction techniques.[11] [12] Of interest in the study, appliance and MELs (miscellaneous electrical loads) not within the control of the design or construction team accounted for 57 percent of the energy load in the house.[13]

Typically a grid-tied house with a small Photovoltaic system cannot produce enough energy to constantly supply the all of the electricity needed, especially at night or on cloudy days. During those times, the utility grid provides the energy. During times of peak sun, the energy though is fed back into the grid. To achieve zero net energy then requires the building to be extremely energy efficient, cutting energy use by at least 70 percent.[14] This can only be achieved using an integrated systems based approach to the design and construction of the house, where each building system is designed to take advantage of the others. An example of this would be the capture of waste heat from the refrigerator and use it to increase the efficiency of the water heater.[15] This type of integration is used in conjunction with a very insulated and airtight building envelope. The alternative approach is to significantly up size the photovoltaic system to offset the lesser efficiency of the remainder of the building and its systems.

While these studies were being performed and published, three documents were introduced that have the potential to significantly alter the efficiency of homes in the future. The National Association of Home Builders (NAHB) published its *Model Home Green Building Guidelines* (GBG)[16] in 2005, which made suggestions on increased building efficiency

11. P. Norton, and Christensen, C., "A Cold Climate Case Study for Affordable Zero Energy Homes," (National Renewable Energy Laboratory, 2006).

12. Of note though, because this home was in a cold climate, there was not a central air conditioning (cooling) system installed, which would have an effect on energy performance in a more temperate climate.

13. Norton, "A Cold Climate Case Study for Affordable Zero Energy Homes."

14. U.S. Department of Energy, "Energy Savings from Small near-Zero-Energy Houses," in Federal Energy Management Program, Technology Installation Review (2007).

15. Ibid.

16. NAHB, "Nahb Model Green Home building Guidelines," (2005).

and materials use to its constituents the home building industry. They later developed the NAHBGreen program to certify projects that used these guidelines. In January 2008, the United States Green Building Council (USGBC) released its LEED for Homes (LEED-H)[17], a building rating system similar to the LEED standard, but specifically for high performance houses. Hoping to create a national standard "green" building code, in 2007 the NAHB joined with the International Code Council (ICC, the organization that develops the International Building Code IBC) to create the 2008 National Green Building Standard (NGBS). On January 29, 2009, the American National Standards Institute (ANSI, the organization that provides standards for everything from products to safety procedures) approved the NGBS. As of this writing, it is unclear whether jurisdictions will adopt either of these rating systems as a baseline or will chose another such as EnergyStar (the Federal EPA/DOE program). Some, such as the State of California, have developed their own code (California Energy Efficiency Standards, effective January 1, 2010).[18]

Energy Use Calculation Methodology

The goal is to determine whether the new multi-use, multi-unit 2 acre block could replace a standard 16 unit two acre single family block in terms of energy use. In determining energy use from the standard single family home, it became clear that determining electricity use would not be possible without taking into account opportunities for building efficiencies. Determining building efficiency on its own requires making many assumptions about the individual building components within the building system, choosing which ones to incorporate, and then designing a prototype for each individual building intended to be included in the model. Even this would require that the building components chosen would be similar to the building components a builder would choose to achieve energy

17. USGBC, "Leed for Homes Rating System," (2009).

18. California Energy Commission, "California Energy Efficiency Standards for Residential and Nonresidential Buildings."

efficiency. The level of efficiency a builder would choose is another major assumption. It was determined that one method to analyze the efficiency of the new model would be to determine whether the cost of building smaller, more efficient homes in greater numbers is equivalent to building standard sized, standard efficiency homes in lesser numbers.

Figures for the standard single family house were obtained from various reports provided by the National Association of Home builders (NAHB). The average size single family home square footage[19] became the base standard home size. This was referenced with national average construction cost figures for single family construction[20] to determine a cost per square foot. These figures were then used to determine a construction cost for a standard single acre 8 unit project (building cost only). The same cost per square foot was then multiplied with square footages for the three plan type efficiency model with 15 units per acre. In construction cost alone, the efficiency model was 16.9 percent less expensive to build.

To determine building efficiency targets, the NAHBs *Green Home Building Rating Systems-a Sample Comparison*[21] (which compares cost of compliance for different rating systems) was reviewed, and it was determined that the efficiency target to use would be NGBSv2 Gold, which corresponded to a similar cost of compliance (7.4% vs. 7.6% cost premium) for LEED-H Silver. To put this in perspective, the NGBSv2 Gold rating requires a home to be 50 percent more efficient than the national IECC standard. The NAHB has determined that the cost of the efficiency components as well as the necessary verification adds 7.4 percent to the construction cost. For this calculation, to

19. NAHB, "Median and Average Square Feet of Floor Area in Detached New One-Family Houses Sold by Location."

20. NAHB Economics, "Construction Cost for Single Family Unit 2007 National Results," (2007).

21. NAHB Research Center, "Green Home Building Rating Systems-a Sample Comparison," (2008).

account for a potential variable of a higher construction cost for a smaller home, a "small premium" of 5 percent was also introduced. The small premium (5%) and the efficiency premium (7.6%) were added to the construction cost of the efficiency model. Even with the increased cost for size and efficiency, the efficient model was still 6.43 percent less expensive to build than the standard acre project.

To determine electricity use, NAHB figures were again used to get a baseline 12 Kilowatt hours (12 KWh) per square foot per year[22] for the standard house. With the choice to use NGBSv2 Gold rating, the 50 percent efficiency of the new units would yield 6 KWh per square foot per year of electricity use. Converting demand to Watt hours per day and multiplying for number of units, the 17 efficiency units per acre require only 55.9 percent as much energy as a the standard 8 units per acre project.

The efficiency measures above represent passive energy measures, in that the units require less energy to operate. To get from efficiency units to Zero Energy Houses requires active measures, mechanical additional equipment for the generation of electricity. At a current installed cost average for the United States of approximately $9 per watt[23] [24], the cost of installing a roof mounted Photovoltaic system to generate all of the electricity required to maintain the home was calculated. To get the efficiency units to a ZEH state cost 9 percent more than the standard units to build. The initial goal was to consider the use of solar water heat and geothermal heat pump space heating, but with the increase in the cost of the energy generation equipment, and not a substantial installed base to determine average costs for these systems, it was

22. NAHB, "Review of Residential Electrical Energy Use Data," (Upper Marlboro, MD2001).

23. Solarbuzz, "Solar Module Retail Price Environment," Solar Photovoltaic, PV Module, Panel Prices.

24. Installed cost is averaged as 2x the price of the panel. At the date of the last website access on 9/21/09, the price of the panel was $4.39 per watt.

Standard Single Family Residence vs. Efficient Home					*energy*
one acre site		Standard Home	Efficient Home		
all sfr option		NAHB	Unit A	Unit B	Unit C
Construction Cost					
House sf		2587	870	1460	1276
finished space sf		753	258	268	264
total finished sf		3340	1128	1728	1540
units / acre		8	4	4	7
cost /sf		$65.57	$65.57	$65.57	$65.57
cost /unit		$219,003.80	$73,962.96	$113,304.96	$100,977.80
total sf		26720	4512	6912	10780
total cost / acre		$1,752,030	$295,852	$453,220	$706,845
cost comparison		***$1,752,030***	***$1,455,916***		
delta (total const. $)		***$296,114***			
		16.90%	*Efficiency acre is 16.90% less expensive*		
efficiency measures			*to build than standard acre*		
small premium /sf	5.0%		$3.28	$3.28	$3.28
small premium /unit			$3,698	$5,665	$5,049
efficiency premium /sf	7.6%		$4.98	$4.98	$4.98
efficiency premium /unit			$5,621	$8,611	$7,674
comparison w/ s&e		***$1,752,030***	***$1,639,362***		
delta (total const. $)		***$112,669***			
		6.43%	*Efficiency acre is 6.43% less expensive*		
mechanical measures			*to build than standard acre*		
geothermal heat pump					
cost premium /sf			$0.00	$0.00	$0.00
cost premium /unit	$3K/t				
solar water heat					
cost premium /sf			$0.00	$0.00	$0.00
cost premium /unit					
Energy Use (for ZEH)					
KWh /sf /year		12	6	6	6
Demand (W/sf)		1.37	0.68	0.68	0.68
Demand /unit (Wh/day)		85052	14301	24000	20975
Demand total			57205	96000	146827
		680416	300033		
		55.90%			
photovoltaic system					
PV cost ($/W installed)	$9		$12,871	$21,600	$18,878
cost premium /unit			$11.41	$12.50	$12.26
PV size minimum (sf)			286	480	420
cost /sf all options (to ZEH)			$85.24	$86.33	$86.09
cost / unit			$96,153.53	$149,181.38	$132,578.81
percentage increase			23.08%	24.05%	23.84%
comparison ZEH		***$1,752,030***	***$1,909,391***		
delta (total const. $)		***-$157,361***	*Efficiency acre is 8.24% more expensive*		
		8.24%	*to build than standard acre for full ZEH*		

Figure 6.27.

Energy Use calculation for acre

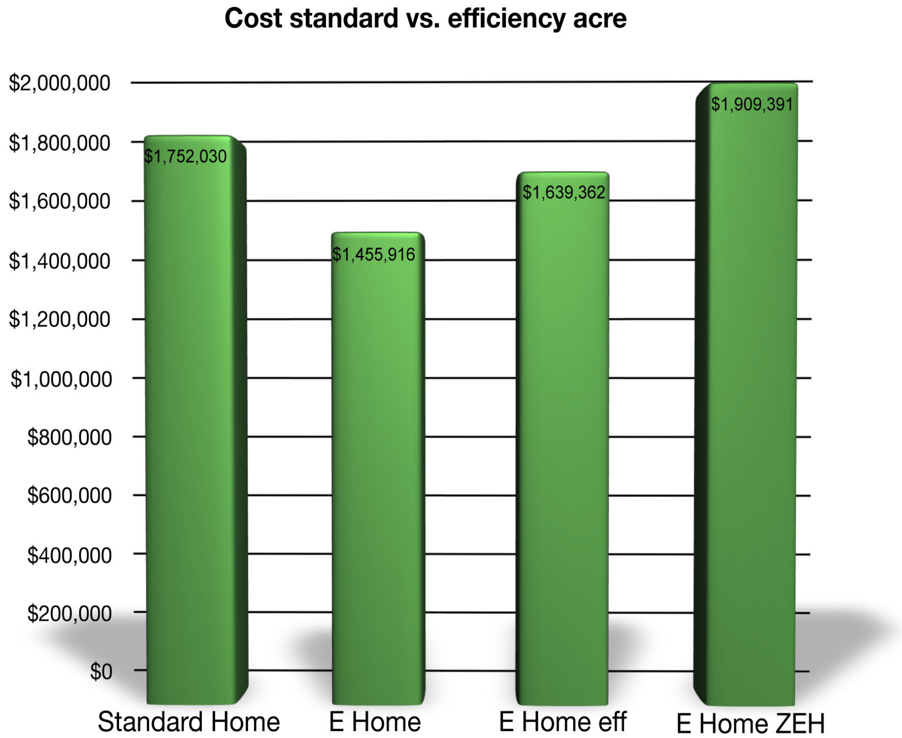


Figure 6.28.
Energy Use chart for single acre

determined that they would not be pursued at this time. On the other hand, the goal of a Net Zero Energy development would be increasingly possible as the cost associated with the generation of energy through Photovoltaic means becomes less over time.

Once the calculations were completed for a 1 acre portion of a block with only single family residences, the same methodologies were performed on an entire block. The block included single family homes, apartments (3 bedroom and studio) and apartments with attached multiuse spaces. Construction costs were obtained through standard of the industry Reed Construction Data.[25] Information on the efficiency cost premium for the apartment was obtained from a Tellus Institute report[26],

25. Reed Construction Data, "Construction Cost Estimate for an Apartment," Construction Cost Estimate for an Apartment (1-3 Story) US National Average | RSMeans Construction Cost Estimating | Reed Construction Data.
26. Bradshaw,et.al., "The Costs and Benefits of Green Affordable Housing," (2005).

Standard Single Family Neighborhood vs. Sustainable Neighborhood										*energy*
full block site		Standard Home	Efficient Home							
multibuilding option		NAHB	Unit A	Unit B	Unit C	Apartment	Studio	Multi /apt 1	Multi /apt 2	Multi /space
Construction Cost										
House sf		2587	870	1460	1276	880	440	1762	2014	1550
finished space sf		753	258	268	264	230	0	0	0	0
total finished sf		3340	1128	1728	1540	1110	440	1762	2014	1550
units		16	4	4	7	8	4	2	2	4
cost /sf		$65.57	$65.57	$65.57	$65.57	$82.33	$82.33	$82.33	$82.33	$55.00
cost /unit		$219,003.80	$73,962.96	$113,304.96	$100,977.80	$91,386.30	$36,225.20	$145,065.46	$165,812.62	$85,250.00
total sf		53440	4512	6912	10780	8880	1760	3524	4028	6200
total cost / site		$3,504,061	$295,852	$453,220	$706,845	$731,090	$144,901	$290,131	$331,625	$341,000
cost comparison		***$3,504,061***	***$3,294,664***							
delta (total const. $)		***$209,397***								
		5.98%	*Efficiency block is 5.98% less expensive to build than standard block*							
efficiency measures										
small premium /sf	5.0%		$3.28	$3.28	$3.28					
small premium /unit			$3,698	$5,665	$5,049					
efficiency premium %			7.60%	7.60%	7.60%	2.42%	2.42%	2.42%	2.42%	1.82%
efficiency premium /sf	7.6%		$4.98	$4.98	$4.98	$1.99	$1.99	$1.99	$1.99	$1.00
efficiency premium /unit			$5,621	$8,611	$7,674	$2,212	$877	$3,511	$4,013	$1,552
comparison w/ s&e		***$3,504,061***	***$3,520,561***							
delta (total const. $)		***-$16,500***								
		-0.47%	*Efficiency block is less than 1% more expensive to build than standard block*							
mechanical measures										
geothermal heat pump										
cost premium /sf			$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
cost premium /unit	$3K/t									
solar water heat										
cost premium /sf			$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
cost premium /unit	$3.5K									
Energy Use (for ZEH)										
KWh/sf/year		12	6	6	6	3.5	3.5	3.5	3.5	0
Demand (W/sf)		1.37	0.68	0.68	0.68	0.40	0.40	0.40	0.40	0.00
Demand/unit (Wh/day)		85052	14301	24000	20975	8438	4219	16896	19312	0
Demand total		1360833	57205	96000	146827	67507	16877	33792	38625	0
		1360833	456833							
		66.43%								
photovoltaic system										
PV cost ($/W installed)	$9		$12,871	$21,600	$18,878	$7,595	$3,797	$15,206	$17,381	$0
cost premium /unit			$11.41	$12.50	$12.26	$6.84	$8.63	$8.63	$8.63	$0.00
PV size minimum (sf)			286	480	420	169	84	338	386	0
cost /sf all options (to ZEH)			$85.24	$86.33	$86.09	$91.16	$92.95	$92.95	$92.95	$56.00
cost / unit			$96,153.53	$149,181.38	$132,578.81	$101,192.37	$40,899.11	$163,782.35	$187,206.38	$86,801.55
percentage increase			23.08%	24.05%	23.84%	9.69%	11.43%	11.43%	11.43%	1.79%
comparison ZEH		***$3,504,061***	***$3,931,710***							
delta (total const. $)		***-$427,650***								
		-12.20%	*Efficiency block is 12.20% more expensive to build than standard block for full ZEH*							
			(geothermal heat pump, solar water heat, and PV)							

Figure 6.29.

Energy Use calculation for total block

and CSBTF report[27] for the multiuse portion of the project.

As with the acre only calculations, the raw construction cost was calculated first, and the efficiency block is almost 6 percent less expensive to building than the standard block. When the energy efficiency cost premiums are added, the efficiency block is less that one half percent more expensive to build than the standard block. With the addition of a Photovoltaic system, the efficiency block is 12.2 percent more expensive to build at Zero Energy. Note that within the energy demand, the multiuse space was not included in the calculations, as

27. Greg Kats, "The Cost and Financial Benefits of Green Buildings," (California Sustainable Building Task Force, 2003).

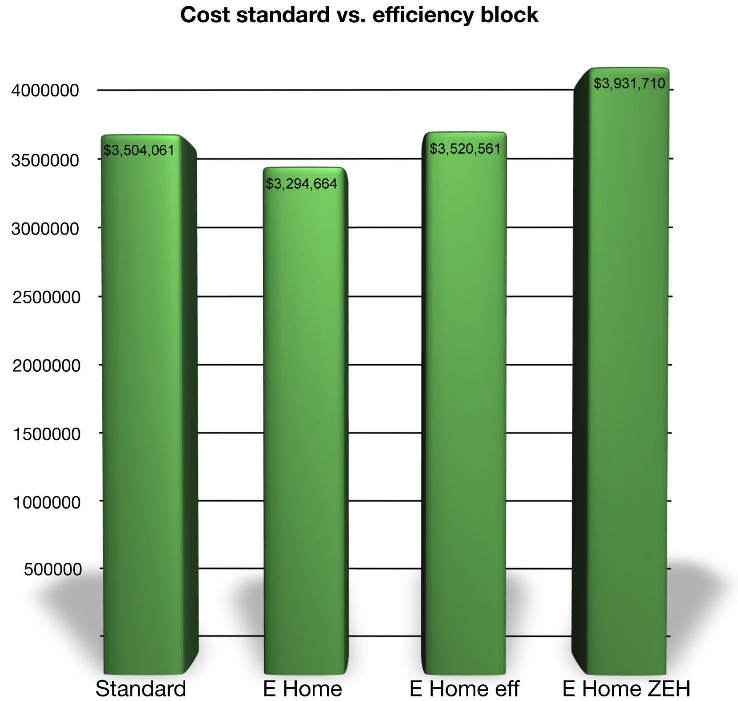


Figure 6.30.
Energy Use chart for total block

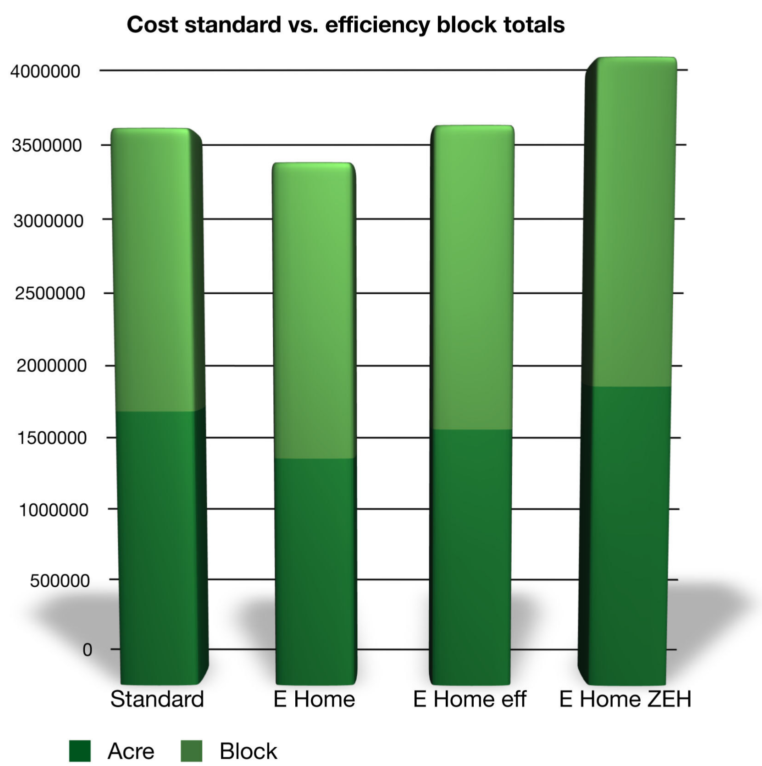


Figure 6.31.
Energy Use comparison chart for total block

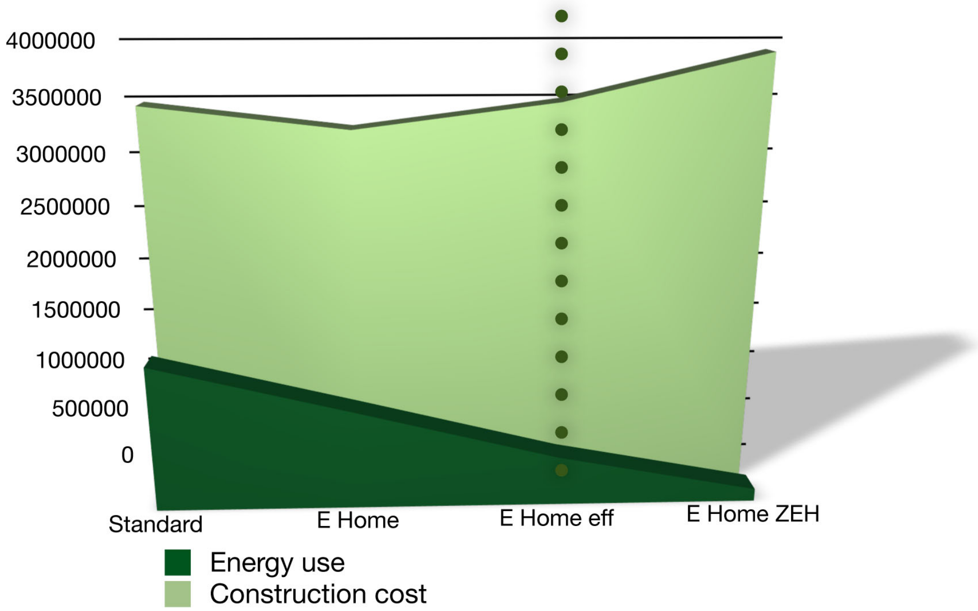


Figure 6.32. *Construction cost vs. energy use*

there is not a standard method of calculating demand for this space. It would be understood that the startup company that would occupy this space would have to provide their own system, based on the demands of their business.

Initial Photovoltaic Research Calculation:
Grid connected, no storage (batteries) necessary.
Sizing: demand: 12KWh psf of house / year .28 (current demand)
12KWh/365=32.8KWh/sf/24h = 1.37W/sf demand
Demand: 1.37W/sf * house sf * 24h = Wh/day
est 1500sf house=1.37W/sf*1500sf*24h= 49,320Wh/day
Supply: roof area * % usable roof area * 10W/sf * peak sun
Supply need: panel size backwards from demand:
49,320Wh/day / 10W/sf / 5 hours ave. peak sun = 986 sf panel

therefore: even using today's electrical demand load figures, 100 percent of electricity demand can be accommodated by solar on the roof of a small house

Figure 6.33. *Initial Photovoltaic sizing calculation*

28. NAHB Research Center, "Review of Residential Electrical Energy Use Data."

Space Heating/Cooling Research: Ground source (or coupled) heat pump.

Geothermal heat pumps are considered a highly efficient renewable source of heat and cooling.[29] Geothermal heat pumps take advantage of the naturally occurring constant temperature of the ground. Typically the temperature of the ground is warmer than the air temperature in the winter, and cooler than the summer air temperature. The heat pump transfers the heat stored in the earth in the winter into the building, and transfers heat out of the building and back into the ground in the summer. A series of pipes are buried into the ground, either horizontally or vertically, and fluid (either water or other refrigerant) is pumped through the pipes. The heat from the earth is either absorbed into the fluid or transmitted from the fluid to the earth, depending on whether the system is heating or cooling. The piping system then transfers the heat into (or collects it from) an air distribution system similar to a central air system.

This type of system uses 25-50 percent less electricity than conventional air conditioning systems, translating to one unit of electricity to move three units of heat.[30] Energy consumption and corresponding GhG emissions are reduced up to 44 percent compared to conventional air heat pumps, and 72 percent versus electric resistance heating.[31] In comparison to common air source heat pumps, this system is quieter, there is no external above ground equipment, they require less maintenance so they last longer, and they are not dependent on the outside air temperature.

The major criticism for this type of system to date is its high up front cost. The installation of this type of system requires burying the piping outside the building, which is where the difference in cost lies, and makes this system up to twice

29. U.S. Department of Energy, "Technologies: Geothermal Heat Pumps," http://www1.eere.energy.gov/geothermal/heatpumps.html.
30. Ibid.
31. Ibid.

as expensive as a conventional air coupled heat pump. The piping in a horizontal application requires plenty of yard space (up to 200 feet in length of pipe for each ton of cooling capacity), but can be located under a driveway. In a vertical application, the same length of pipe is drilled down into the earth. The high up front cost is typically offset by a significant reduction in electricity to run the system. In the case of this research, the cost of the system will be more than offset by the elimination of the natural gas system and its infrastructure in its entirety. As an added benefit, in a systems approach to design, the geothermal heat pump system can also act as a backup heat source for the solar water heater, or even replace the solar heater as a single heat source for water and space heating and cooling. Initial calculations concluded that with solar water heat and efficient electrical geothermal heat pump, the gas utility can be eliminated.

Water Heat Initial Research: solar with heat pump backup
Sizing: demand: 20 sf collector area / person for first 2 people, + 8sf each additional 1.5 gal of storage per sf collector area 32
3 people: 20 + 20 + 8 = 48sf collector, 32 gallons of storage
(50 gal is typical minimum tank size)

Figure 6.34.
Initial Solar Water Heat sizing calculation

Based on the later research, it was determined that pursuing the solar water heat and geothermal heat pump options had the potential to not be cost effective within the context of the new development model. The building efficiency practices, as described by Brian McKay Lyons[33] and Peter Pfeiffer[34] were considered the most appropriate approach, so the focus of the research headed away from including higher-cost active mechanical systems.

32. Energy Efficiency and Renewable Energy Clearinghouse, "Solar Water Heating," http://www.toolbase.org/Design-Construction-Guides/Plumbing/solar-water-heating.
33. Fettig, "Village Architect."
34. Snider, "Mainstream Green: Architect Peter Pfeiffer Makes a Case for the Everyday Sustainable Home."

Water Use.

The average household uses 160 gallons of potable water per day per capita.[35] Of that total 58% or 93 gallons is used to water the landscaping. This equates to an indoor water use of 67 gallons per day per capita. The largest user of water inside the house is the toilet, which consumes 31% or roughly 20 gallons of water per person per day. The water used for flushing the toilet is considered black water, unusable once it goes through the toilet. The balance of that water, approximately 47 gallons, is gray water from the washing machine, dishwasher, showers and sinks in the typical home. This water can be put to use as it is without treatment to water the landscaping. Most jurisdictions will not allow gray water to become airborne, so they require gray water landscape irrigation to be used with a drip-irrigation system.[36]

In a arid western region, converting at least 500 square feet of turf on a single family lot with xeriscape (low water consumption) materials resulted in a 30% decrease in water use, a savings of 96,000 gallons of water per year per household.[37] This translated into planting xeriscape materials instead of turf results in a 76.4% decrease in water use per square foot of planted yard surface area.

Initial Water Reduction Research Calculation:
93 gal landscaping use – 10% over watering = 84 gal landscaping use
84 gal landscaping use – 25 gal (30% decrease for xeriscape) = 59 gal landscaping use. 59 gal * 50% reduction for drip irrigation = 31 gal landscaping use.
Can be further reduced for total xeriscape (no turf)
67 gal household use – 20 gal toilet use = 47 gal gray water
47 gal gray water – 20 gal toilet use = 27 gal gray water
Household water demand drops to 47 gallons.
27 gal gray water for landscaping use, 31 gal demand (xeriscape with turf)

Figure 6.35.
Initial water use reduction calculation

35. P.W Mayer, DeOreo, W.B., et.al,, "Residential End Uses of Water," (American Water Works Association Research Foundation, Denver, 1999).
36. Arizona Department of Environmental Quality, "Using Gray Water at Home," ed. Arizona Department of Environmental Quality (Phoenix 2001).
37. Kent Sovocool, "Xeriscape Conversion Study Final Report," (Southern Nevada Water Authority, 2005).

The AWWA indicated in 1999 that if all households installed currently available water saving plumbing fixtures, indoor water use would decrease 30%, saving 5.4 billion gallons of potable water per day.[38] In a more recent study that took into account advances in water saving devices in common use in 2003, the EPA's WaterSense program determined that efficiency measures using today's commonly available technology can result in a 21% reduction in indoor domestic water use.[39] Included within the above calculation, interior water demand per capita per day drops to 37.2 gallons. As part of the efficiency measures, toilet water use drops from 20 gallons to 6.5 gallons.

67 gal household use – 14.1 gal (21% efficiency reduction) = 52.9 gal interior use
52.9 gal household use – 6.5 gal toilet use = 47.1 gal gray water
47.1 gal gray water – 6.5 gal toilet use = 40.6 gal gray water
40.6 gal gray water for landscaping use, 31 gal demand (xeriscape with turf)

therefore: when combined with a xeriscape planting scheme, grey water can be used to meet total demand for landscaping

Figure 6.36.
Initial Grey water calculation

Water Use Calculation Methodology:

As is the case for energy use, the goal is to determine whether the new multi-use, multi-unit 2 acre block could replace a standard 16 unit two acre single family block in terms of water use. Calculations were not performed on a single acre basis as was done with the energy use calculation.

Water use for single family residences is measured in gallons per capita per day. Water use for multifamily residences is calculated per unit. Both the standard home as well as all of the various efficiency unit types were reviewed for number of bedrooms. The first bedroom was counted as two occupants, each additional bedroom as one. Total occupants for each type of unit were determined, as was

38. Mayer, "Residential End Uses of Water."
39. EPA, "Water Efficient Single Family New Home Specification," (Environmental Protection Agency WaterSense, 2008).

Standard Single Family Neighborhood vs. Sustainable Neighborhood										*water / sewer*
full block site		Standard Home	Efficient Home							
multibuilding option		NAHB	Unit A	Unit B	Unit C	Apartment	Studio	Multi /apt 1	Multi /apt 2	Multi /space
Unit Configuration										
House sf		2587	870	1460	1276	880	440	1762	2014	1550
Bedrooms		3	1	3	2	3	1	3	3	
Baths		2.5	1.5	2.5	1.5	1	1	2.5	2.5	
Occupants		4	2	4	3	1	1	1	1	
units		16	4	4	7	8	4	2	2	4
total occupants		64	8	16	21	8	4	2	2	0
indoor water/capita (gal/day)		67	67	67	67	121	121	121	121	121
outdoor water/capita (gal/day)		93	93	93	93	93	93	93	93	93
total water/capita (gal/day)		160	160	160	160	214	214	214	214	214
total water/unit type in (gal/day)		4288	536	1072	1407	968	484	242	242	0
total water/unit out		5952	744	1488	1953	744	372	186	186	0
total water/unit in/out		10240	1280	2560	3360	1712	856	428	428	0
demand comparison	***indoor***	***4288***	***4951***	61						
delta (gallons/day)		***663***								
		13.39%	*Efficiency block requires*		13.39%	*more water than standard block*				
efficiency measures indoor										
efficiency reduction %	(waterwise)		21%	21%	21%	21%	21%	21%	21%	21%
efficiency indoor			52.9	52.9	52.9	95.6	95.6	95.6	95.6	95.6
efficiency /unit type			423.4	846.9	1111.5	764.7	382.4	191.2	191.2	0.0
demand comparison in w/e		***4288***	***3911.3***							
delta (gallons/day)		***-376.7***								
		-9.63%	*Efficiency block requires*		9.63%	*less water than standard block for interior use*				
efficiency measures outdoor										
xeriscape										
efficiency reduction %			30%	30%	30%	30%	30%	30%	30%	30%
efficiency outdoor			65.1	65.1	65.1	65.1	65.1	65.1	65.1	65.1
efficiency/unit type			520.8	1041.6	1367.1	520.8	260.4	130.2	130.2	0
demand in/out w/ xeriscape		***10240***	***7882.39***							
delta (gallons/day)		***-2357.6***								
		-29.91%	*Efficiency block requires*		29.91%	*less water than standard block for interior/exterior use*				
drip system										
efficiency reduction %			50%	50%	50%	50%	50%	50%	50%	50%
efficiency outdoor			32.6	32.6	32.6	32.6	32.6	32.6	32.6	32.6
efficiency/unit type			260.4	520.8	683.6	260.4	130.2	65.1	65.1	0
demand in/out w/ x & drip		***10240***	***5896.8***							
delta (gallons/day)		***4343.2***								
		42.41%	*Efficiency block requires*		42.41%	*less water than standard block for interior/exterior use*				
grey water										
wastewater			52.9	52.9	52.9	95.6	95.6	95.6	95.6	95.6
toilet use (blackwater)			6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5
waste available for grey			46.4	46.4	46.4	89.1	89.1	89.1	89.1	89.1
flush toilet w/ grey			6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5
grey available for LS			39.9	39.9	39.9	82.6	82.6	82.6	82.6	82.6
grey available/unit			319.4	638.9	838.5	660.7	330.4	165.2	165.2	0.0
demand in less flush/unit			371.4	742.9	975.0	712.7	356.4	178.2	178.2	0.0
demand in less toilet		***4288***	***3514.8***							
delta (gallons/day)		***-773.2***								
		-22.00%	*Efficiency block requires*		22.00%	*less water than standard block for interior use*				
water demand for LS w/ x & drip		***1985.6***	***3118.3***							
total grey available		***3118.3***								
delta (gallons/day)		***1132.7***								
		36.33%	*Efficiency block generates*		36.33%	*more water for landscaping than is required*				
sewer system										
fluid total/unit type		4288	423.4	846.9	1111.5	764.7	382.4	191.2	191.2	0.0
fluid total / block		***4288***	***3911.3***							
delta		***-376.7***								
		-9.63%	*Efficiency block generates*		9.63%	*less water than standard block*				
water demand for landscape			260.4	520.8	683.6	260.4	130.2	65.1	65.1	0.0
grey usable for landscape			319.4	638.9	838.5	660.7	330.4	165.2	165.2	0.0
extra grey to sewer system			59.0	118.1	155.0	400.3	200.2	100.1	100.1	0.0
blackwater/unit type			52	104	136.5	52	26	13	13	0
fluid into system w/ grey			111.0	222.1	291.5	452.3	226.2	113.1	113.1	0.0
fluid total/block		***4288***	***1529.2***							
delta		***2758.8***								
		64.34%	*Even with excess greywater into system, efficiency block puts 64.34% less fluid into the sewer than standard block*							

Figure 6.37.
Water Use Calculation

total occupants per unit type. Water use per occupant (per capita) was taken from the Mayer report for the American Water Works Association (AWWA).[40] Water use data for multifamily units was taken from a Department of Energy (DOE) report.[41] Water use was split between indoor use and outdoor (landscaping) use. Water demand for the entire block was calculated for indoor use only. The efficiency block required 13.39 percent more water than the standard block, due to number of occupants being significantly higher. Next, indoor demand was calculated after assuming water efficient fixtures in the efficiency units based on the EPA's WaterSense program.[42] This program calculated a 21 percent decrease in water usage with efficient fixtures. Calculations done in the AWWA predicted a 30 percent reduction in water usage with efficient fixtures.[43] The more conservative 21 percent was used in the calculations. With the water efficient fixtures, the efficiency block used 9.63 percent less water indoors than the standard block.

The next calculation looked at total (indoor and outdoor) demand, including the efficient fixtures. Added to the calculation then was efficient outdoor water use with xeriscaping. According to Sovocool, xeriscaping has the potential to decrease landscaping water use by 30 percent.[44] With these efficiency measures, water use for the efficiency block was 29.91 percent less total water than for the standard block. The next variable added was landscaping watering through a drip irrigation system. This system reduces water consumption by 50 percent. When combined with the other efficiency measures, the efficiency block uses 42.41 percent less water than the standard block.

Figure 6.38.
Xeriscaping

40. Mayer, "Residential End Uses of Water."
41. Department of Energy (DOE), "2004 Water Use in Multifamily Housing Units."
42. EPA, "Water Efficient Single Family New Home Specification."
43. Mayer, "Residential End Uses of Water."
44. Sovocool, "Xeriscape Conversion Study Final Report."

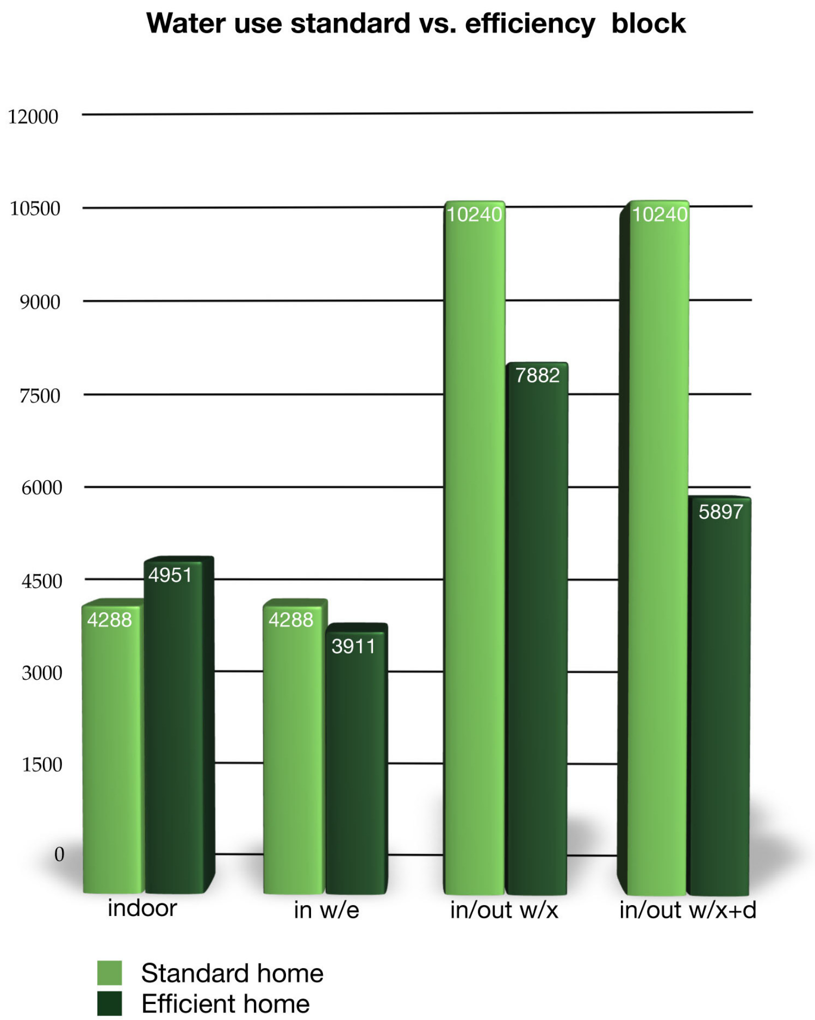


Figure 6.39.
Water Use Comparison chart

Grey water Calculation Methodology:

In calculating grey water use, it was assumed that all of the indoor water use became wastewater. Subtracting the EPA's calculation for toilet use, yields wastewater available for grey water use. Using available grey water to flush the toilet yields grey water available for landscaping use. Utilizing grey water to flush the toilet, interior water demand for the efficiency block is 22 percent lower than the standard block. Calculations then determined the water demand for outdoor landscaping use. Utilizing the efficiency measures of xeriscaping and drip irrigation with a grey water system, the efficiency block generates 36.33 percent more grey water than is required for the landscaping.

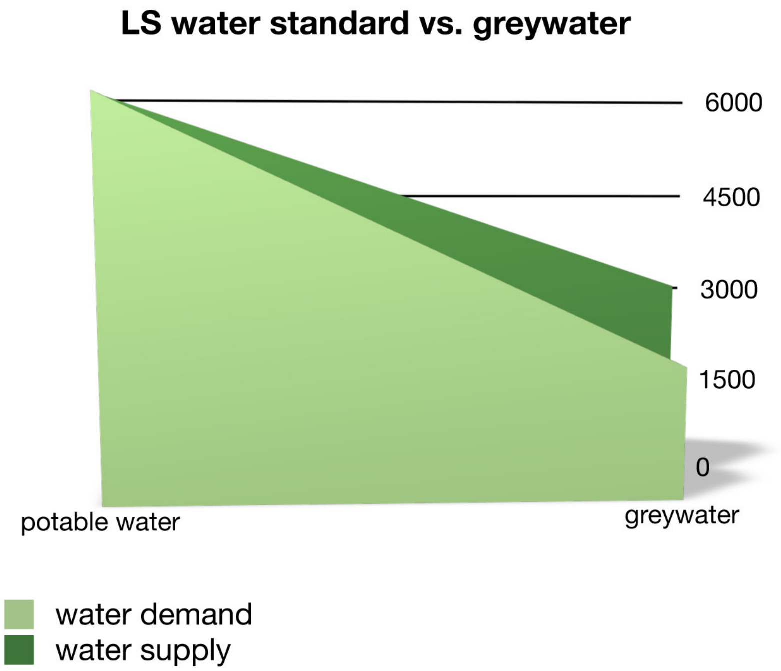


Figure 6.40.
Grey water Landscape Use chart

Initial Sewer Fluid Research Calculation:

Domestic wastewater flow per person varies with the number of persons in a household. The fewer persons in a household, the higher flow per person. A typical flow rate for a two person household is 76 gal/capita, with a four person household the number drops to 53 gal/capita.45 For calculation purposes, we will use a three person household per capita flow rate of 66 gallons46, which is consistent with the incoming water demand of 67 gallons per capita per day indicated above.

Using the calculations for potable water demand (without water saving devices) above, just by switching to a gray water system, including using gray water to flush the toilets, we divert 47 gallons of water per capita per day out of the public sewer system, a decrease of 70 percent. Using water saving technologies and the gray water system, the only water going into the system will be the reduced black water flow from the toilet. At 6.5 gallons of black water effluent per capita per person per day, this amounts to a reduction of over 90 percent of the wastewater being directed into the public sewer system. What is unknown at this point is if this substantially reduced amount of fluid is actually sufficient to move the dissolved solids through the system.

therefore: It is possible to significantly increase the density while remaining within the capacity of the typical public sewer system

Figure 6.41.
Initial Sewer Fluid calculation

45. et. al. Sendich, Planning and Urban Design Standards, ed. Emina Sendich, First ed. (Hoboken: John Wiley and Sons, 2006).
46. Ibid.

Sewer Fluid Calculation Methodology:

Again, it was assumed that all of the indoor water use became wastewater. Calculations indicate that without grey water, the efficiency block puts 9.63 percent less fluid into the sewer system. From the grey water calculations, the amount of black water (water from toilet only) was calculated as was the amount of grey water used for the landscaping. Assuming that excess grey water (that not used for landscaping) would be put into the sewer system with the black water, it was determined that, even with the excess grey water, the efficiency block puts 64.34 percent less fluid into the sewer system than the standard block.

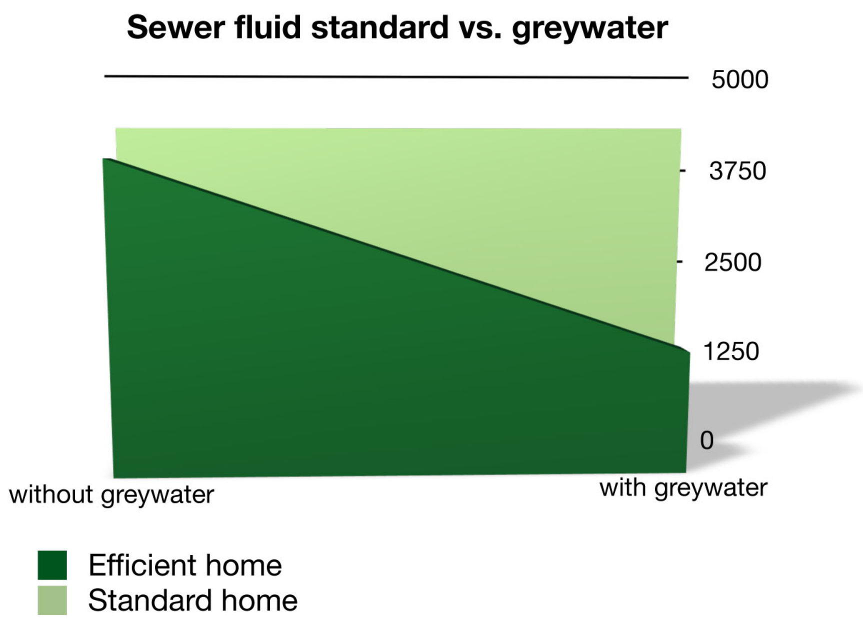


Figure 6.42.
Sewer Fluid chart

Storm Drain Research:

Because sizing of storm drain systems is based on rainfall, calculating for a typical rainfall for the entire country would not prove optimal. In the context of this research, we will integrate Low Impact Development [47] design methods into the project. Within these methods, which were originally developed by the Prince George's County Maryland Department of Environmental Resources[48]

47. Low Impact Development Center, "Urban Design Tools for Low Impact Development," http://www.lid-stormwater.net/background.htm.
48. PGCDER, "Bioretention Manual," (Prince George's County Maryland2001).

for bioretention for storm water quality, storm water runoff into the storm drain system will be significantly reduced. These methods will include permeable paving materials and bioretention (within greenspace connectivity areas), but may also include cisterns and green roofs.

Storm Drain System Capacity Methodology:

To determine storm drain capacity in a prototypical situation is not possible. Storm drain size is calculated based on historic rainfall calculations and ability of the soil type to absorb the storm water from various size storms. Without fixing the location of the prototype model, that data is not available. The intent of the research is to determine whether existing systems are impacted to a greater extent with the increase in density. To determine the effects on the storm drain system, the decision was made to focus on the ability of the new model to absorb storm water through calculating pervious surfaces. The implication was that if the pervious surface of the new higher density model was lesser than the standard block, then more of the storm water would end up in the storm drain, overtaxing the system. The pervious surface of the standard block was calculated, including the entire site save for the building foot print and the driveway. This methodology would prevent the variables involved in determining patio and walkway area when these areas are personalized by individual homeowners. In the same manner, on the prototype model, patios and walkways were not designed or included within the calculation. One difference within the site layouts is that the new model assumes a pervious pavement surface for the driveway area. Also, for purposes of calculation, the

Figure 6.43.
Bioswale retaining water

Figure 6.44.
Bioswale within parkway
Denver, CO

impervious surfaces of the streets and sidewalks were not calculated. It would be assumed that with the decrease in street width, along with the potential for pervious sidewalk surfaces on the new model, that there is the potential for increase in permeable surface off site as well. The calculations indicate that the standard block is 55 percent impervious area. In the new model, even with the increase in density, impervious area is reduced to 40 percent, a 15 percent reduction. So the conclusion is that an increase in density within the new model has the ability to reduce the amount of storm water in the storm drain system. Additionally, the new model provides for a large open common green space within the center of the block. Using low impact design for storm water and biofiltration, with a bioswale in the common space it is conceivable that there is even greater reductions in the amount of storm water flow, and a greater recharge of the underground aquifers.

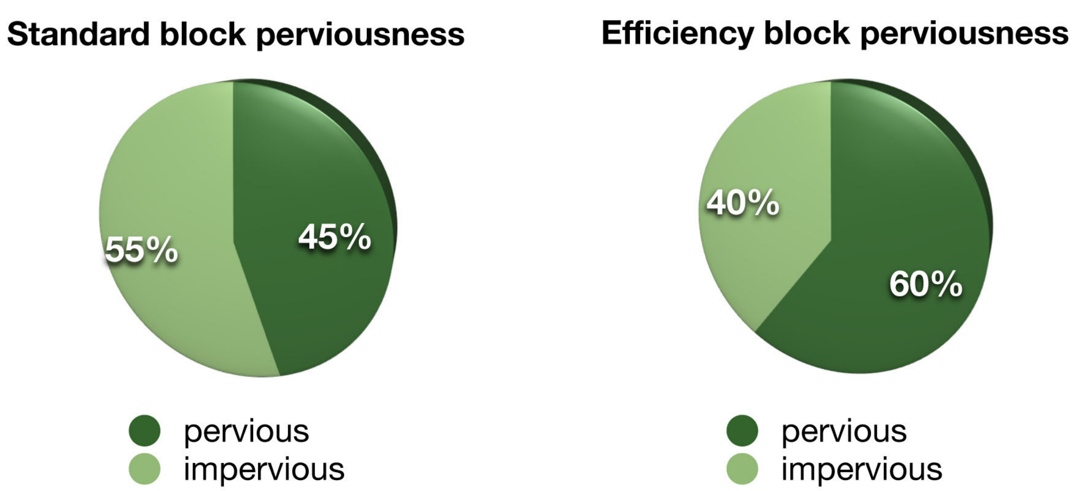


Figure 6.45.
Perviousness chart

Community.

In this research houses will be placed in specific locations on sites, and will relate to each other. There will be provisions for outdoor living spaces related to adjacent indoor uses. In this manner, a variety of housing types and sizes can be accommodated. With multiple housing types, opportunities for affordability for multiple economic strata will occur. By providing multi-use spaces for innovation and new business development, economic sustainability can be augmented. Providing these places will also allow for the reduction in car use, and thus the reduction in on site parking spaces.

Figure 6.46.
High Point neighborhood
Seattle, WA

Provisions will be made for private as well as common green space, which will double as infiltration for storm water as required. These green spaces will be connected through the block, and to the adjacent blocks. Pedestrian connectivity will follow these spaces as well. The reduction in street width and provisions of parkway and sidewalk will frame the street in a proportion more appropriate for pedestrian scale.

As mentioned earlier, the ability to mix uses within the block will provide the opportunity for a diversity of uses within a neighborhood. As such, there will be the ability for place making, for making memorable places and promoting community through changes in densities, availability of businesses and services, and connectivity to the balance of the neighborhood and beyond.

Figure 6.47.
Emoryville Lofts Mixed Use
Emoryville, CA
David Baker & Partners

The actual layout of the blocks in the model are based on the individual block size used in the balance of the research. This provides a basic framework to illustrate that different block configurations are possible. Within the multiple block example opportunities for differing block lengths, curved blocks to fit within existing rights of way, or other site specific ideas were not explored. These options, as well as provisions for individual "signature" buildings, higher density, landmarks and adjustments for topography or other land features are all possible. It is these types of adjustments in a specific location that will make for memorable experiences, and ultimately contribute to the sense of community.

Opportunities for community:

Opportunity for jobs: Within the single family standard community, businesses are regulated out of the neighborhood by zoning. Within the new model, employment opportunities exist within the multi-use building type, as well as the storefront/office building type. Within the new model community, it is possible to walk to work.

Figure 6.48.
Neighborhood services
Rosemary Beach, FL
DPZ

Opportunity for services (public and civic): To get to services within the single family standard neighborhood means driving to those services, because zoning will not allow them to be located in the same zone as the houses themselves. Within the new model, these services may be at the end of the block, or within a five minute walk.

Diversity of housing types: within the single family suburban standard block, the home buyer is given the choice typically of three houses that fit within the same lot. There is usually a small range of feature differences, as well as a slight change in square footage based on market studies. In the prototype model, there is a range of housing opportunities from studio apartments, to single family homes, to multiuse units with housing for a total of nine different housing opportunities within a given block.

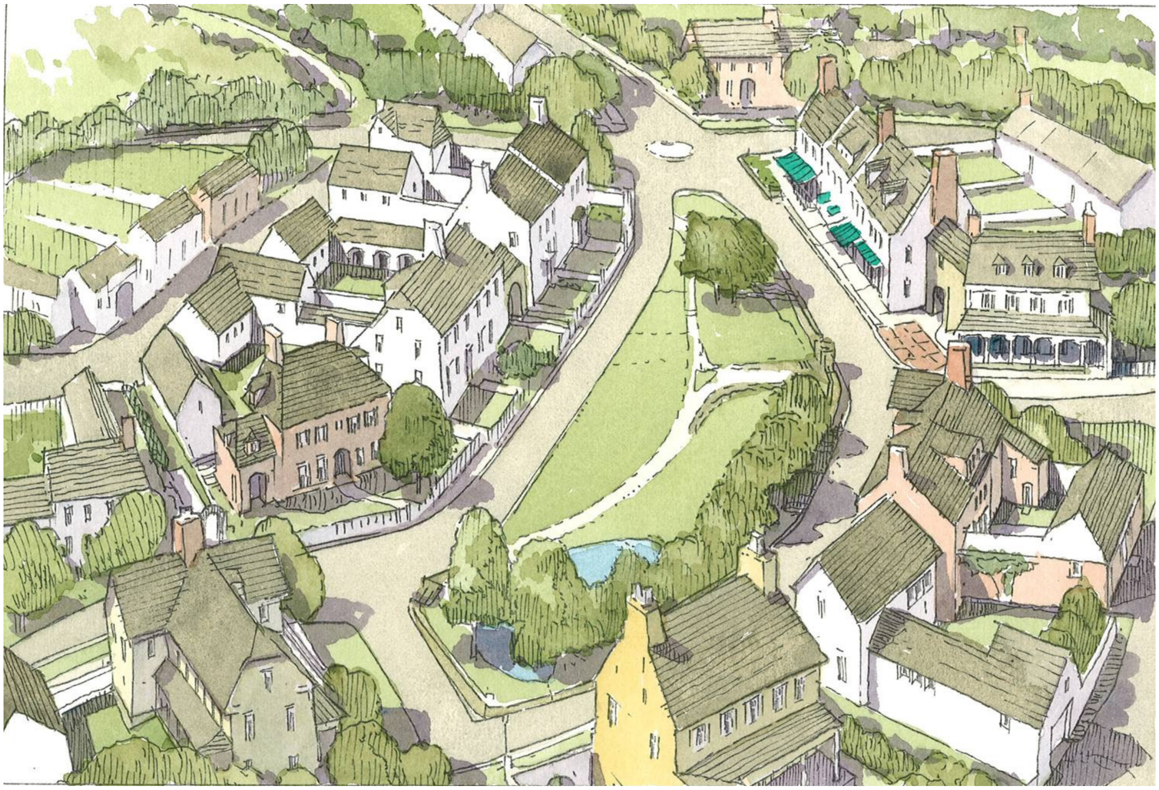


Figure 6.49.
Liberty, MO
DPZ

Opportunity for neighbor interaction: Because the standard single family home community is car-centric, opportunity to interact with your neighbors is limited. Within the new model, there are more opportunities for interaction: walking to neighborhood services, common green space, porches on pedestrian scaled streets.

Economic diversity: within the single family suburban standard block, the singularity of housing brings with it a singular group of individuals that can afford to live within it. With a diversity of housing types in the new model, the opportunity for diversity within the homeowners in the block increases.

Public and Private greenspace: In the research, it has been shown that although there is greenspace per home within the standard single family block, it is private greenspace. Within the new model block, there is both private greenspace and common green space. The common greenspace is also connected block to block.

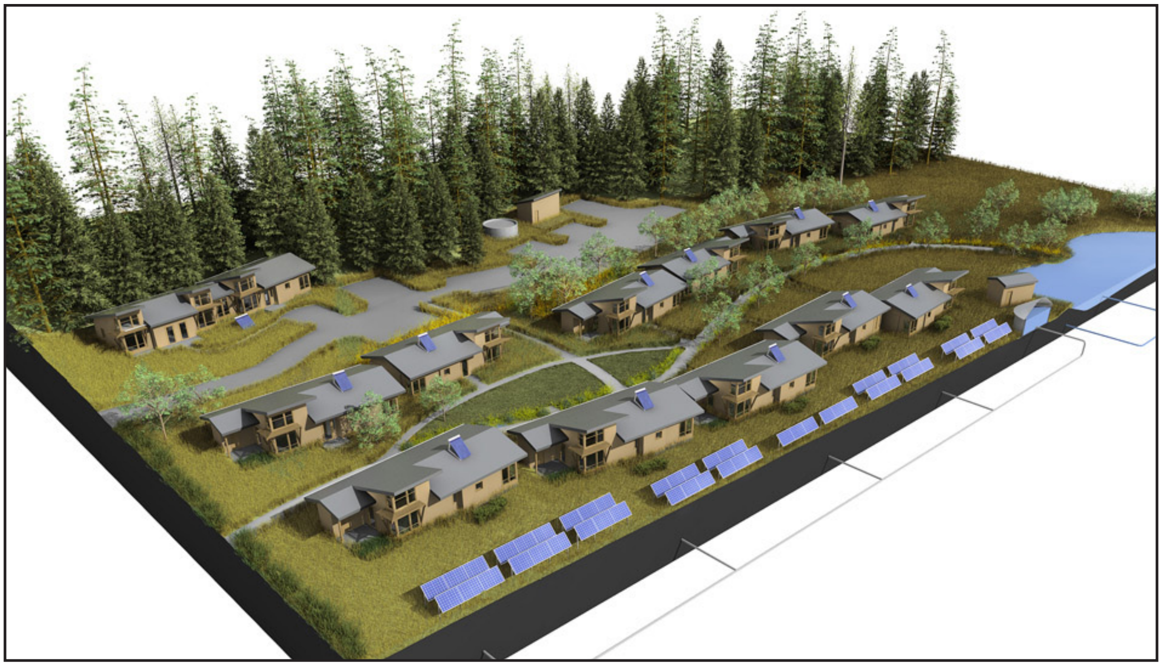


Figure 6.50.
Net Zero Workforce Housing Lopez Island, WA Mithun Architects

Walkability/bikability: In the standard suburban block, the sidewalks follow the streets, and the streets do not make direct connections. Within the new model, opportunities exist for pedestrian scaled, connected access throughout the neighborhood. In an August 2009 study, houses within a neighborhood with an above average walkability commanded between $4000 and $34,000 more than houses within a neighborhood with average walkability.[49]

Connectedness: In the standard suburban block, the streets do not make direct connections, making it inconvenient to move from one place to another. Within the new model, enhanced connections within the car as well as the opportunity for connected pedestrian routes, including connected greenspace are possible. Streets are laid out in a hierarchy, from primary collector roads (where there is the potential for a connection to a bus stop for connectedness to

49. Joe Cortright, "Walking the Walk, How Walkability Raises Home Values in U.S. Cities," (CEOs for Cities, 2009).

Figure 6.51.
Shared Street/ pedestrian connection
Urban Tree
Seattle, WA
b9 Architects

adjacent communities) to secondary streets, to shared streets,[50] where the pedestrian and bicycle are as important as the car.

Compactness of Development: The new model provides for more compact development. According to a survey by NAHB Economics, gasoline consumption and its attendant CO2 emissions decline as the compactness of subdivisions increases.[51] The report also makes the point that, as density increases, the speed of vehicles is slowed, which has an adverse effect on gasoline consumption efficiency. As subdivision density increases over 7.8 units to the acre, the optimal traffic speed (45 mph!) decreases by 25.4 mph. Even with this decreased car efficiency, compact development still produces less CO2 emissions.[52]

50. Michael Southworth, and Ben-Joseph, Eran, Streets and the Shaping of Towns and Cities (Washington: Island Press, 2003).
51. NAHB Economics, “Vehicle Co2 Emissions and the Compactness of Development,” (2007).
52. Ibid.

Figure 6.53.
(below) the Union compact development San Diego CA Jonathan Segal Architects

Figure 6.52.
(above) Urban Canyon compact development Seattle, WA b9 Architects

Ultimately, the new model provides the framework for community to develop on its own, by providing a diversity of housing opportunities, business opportunities, and ultimately of experiences within the neighborhood. Collectively over time it is these experiences that make community.

Figure 6.54.
Community at the micro scale: Cheesecake Consortium Cohousing Mendocino, CA Fernau and Hartman Architects

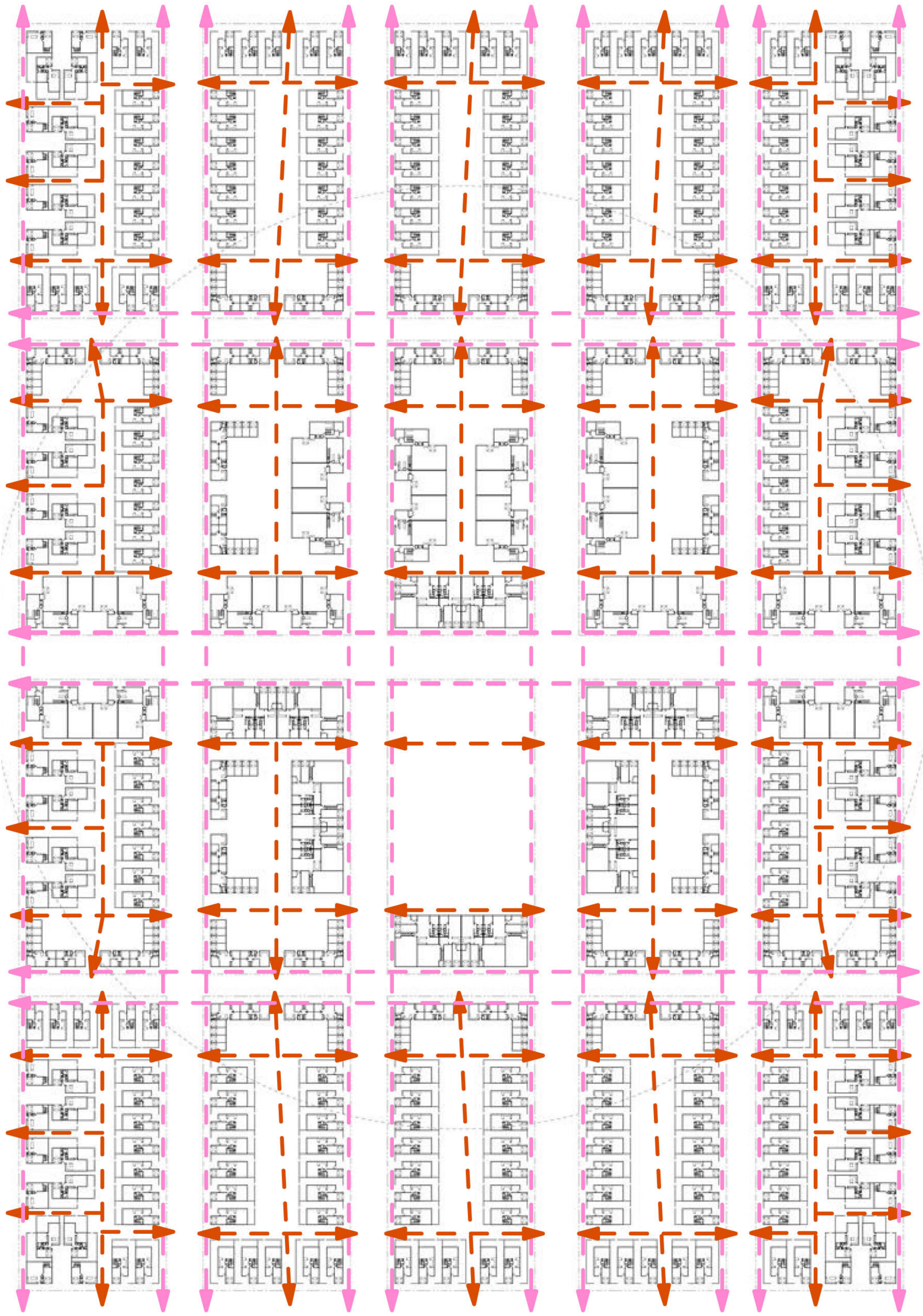


Figure 6.55.
Conceptual Neighborhood diagram
Pedestrian Connectivity

Figure 6.56.
Conceptual Neighborhood diagram
Street Hierarchy

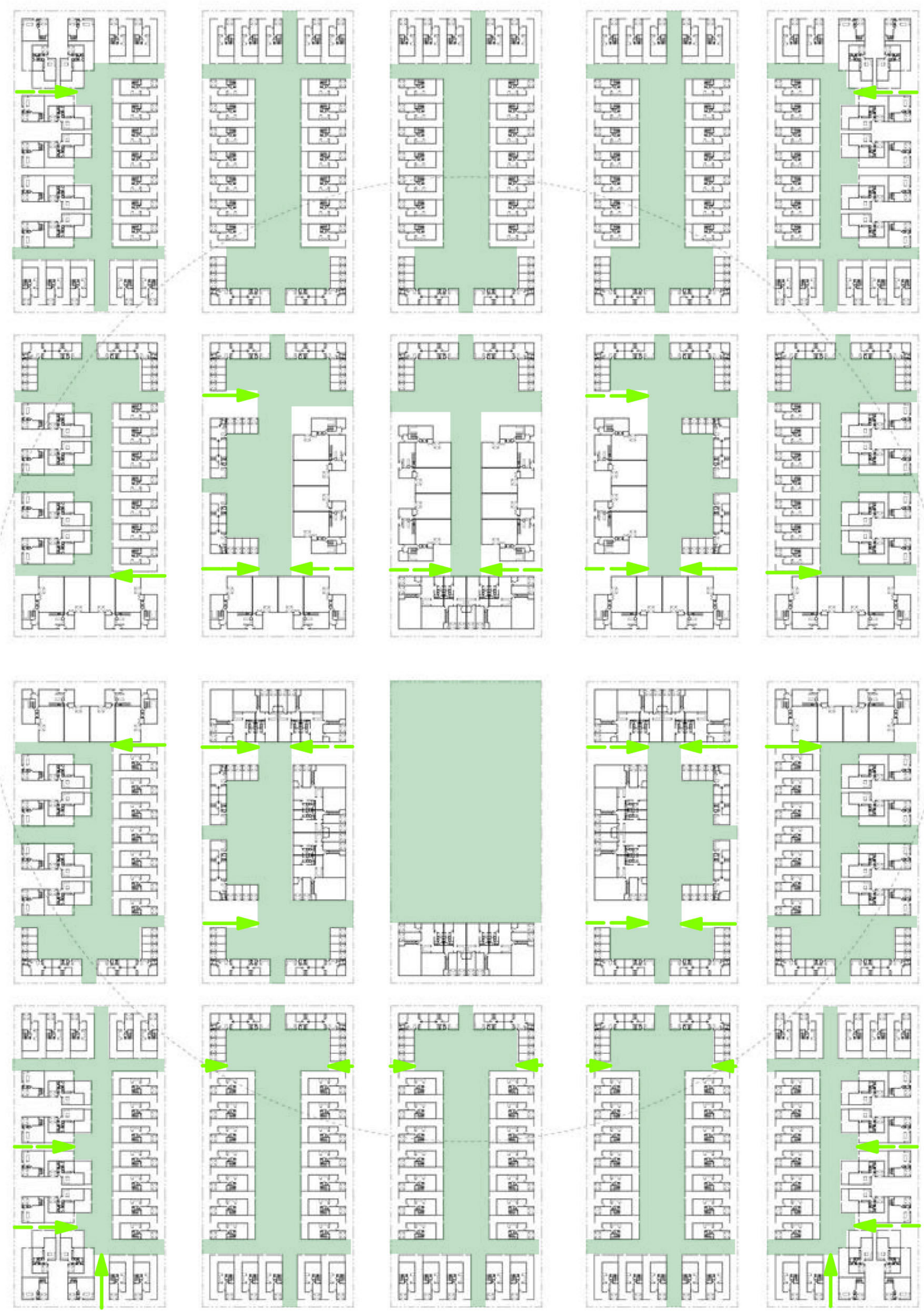


Figure 6.57.
Conceptual Neighborhood diagram
Green Connectivity

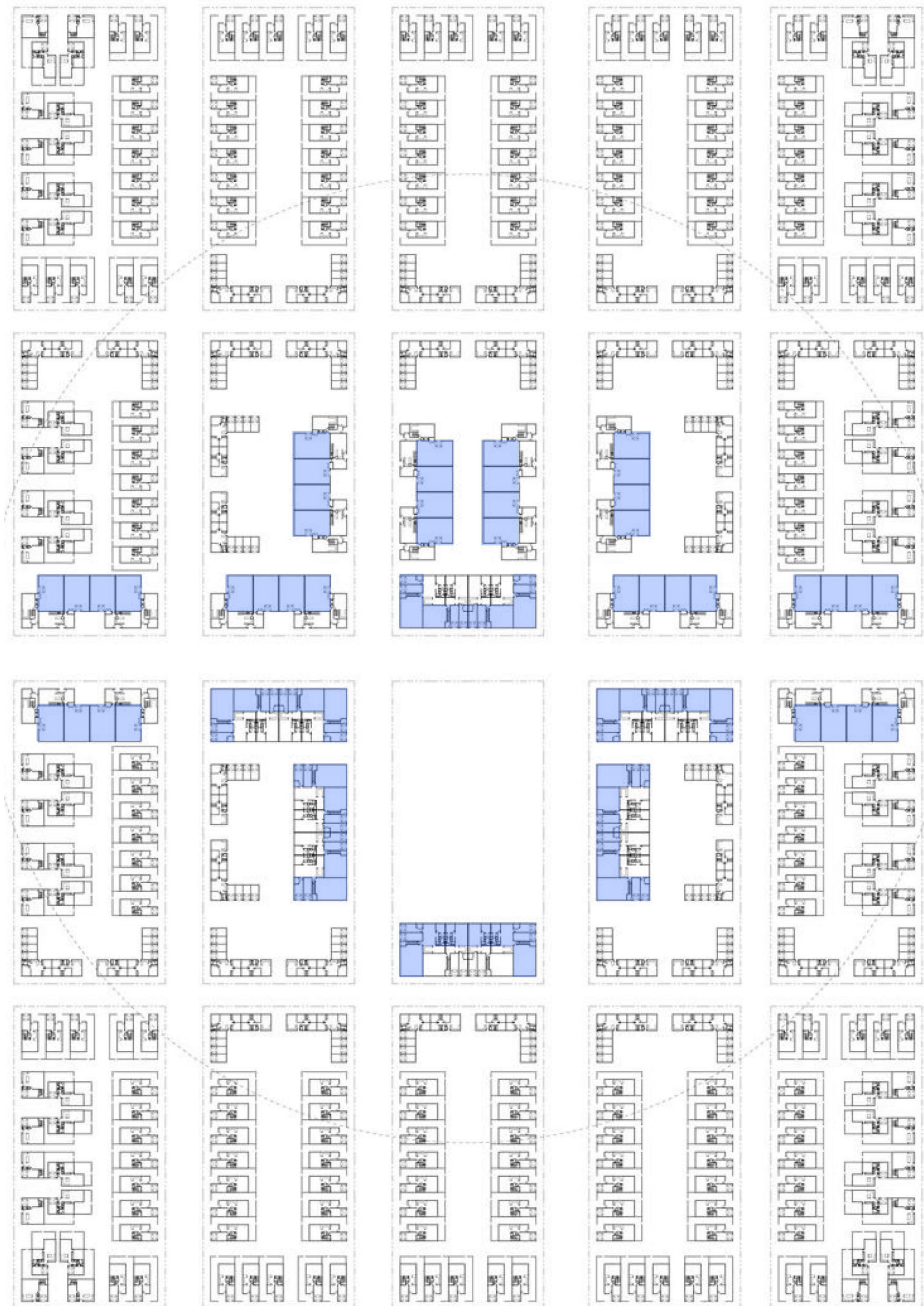


Figure 6.58.
Conceptual Neighborhood diagram
Business Incubator opportunity

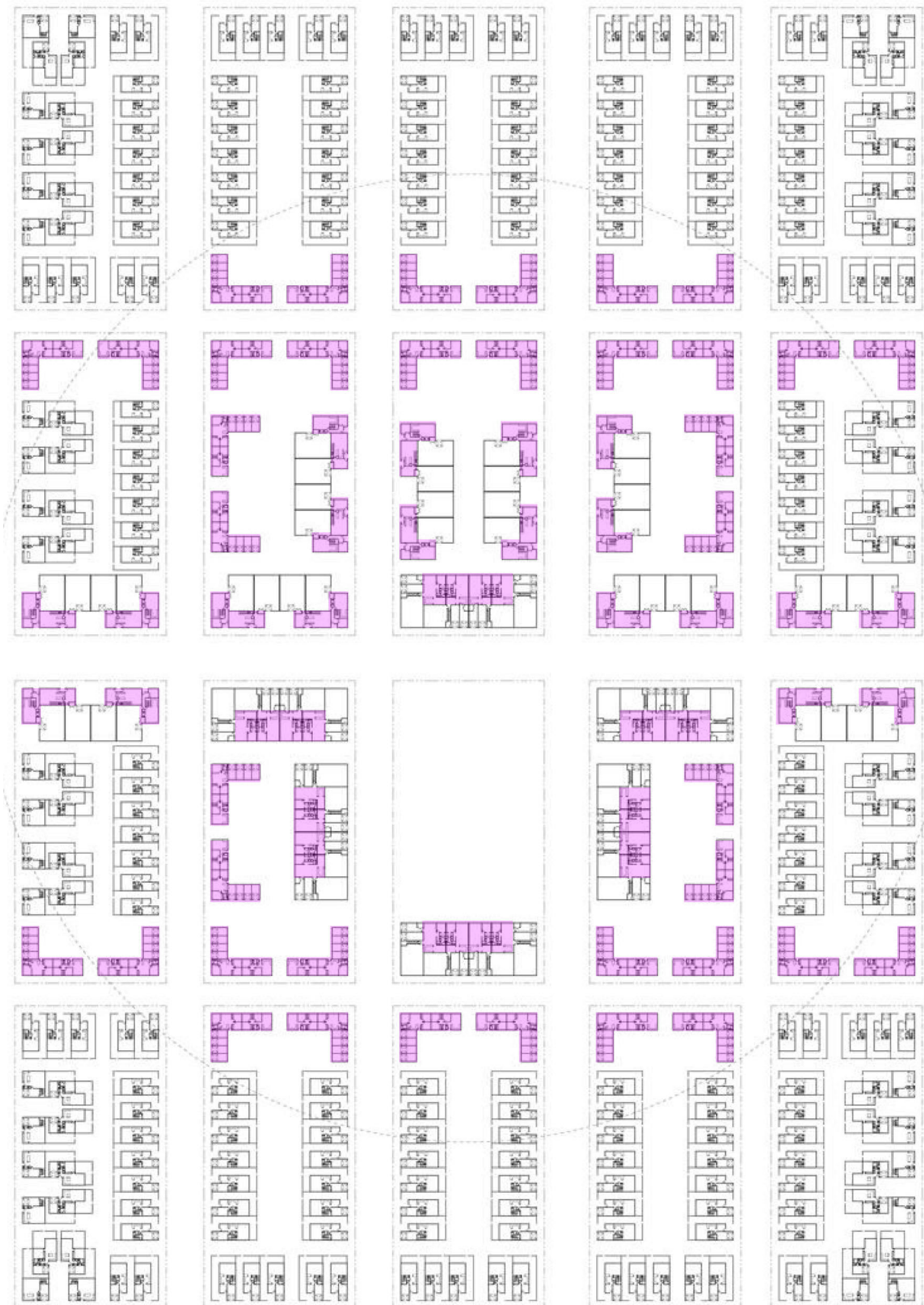


Figure 6.59.
Conceptual Neighborhood diagram Multifamily Housing

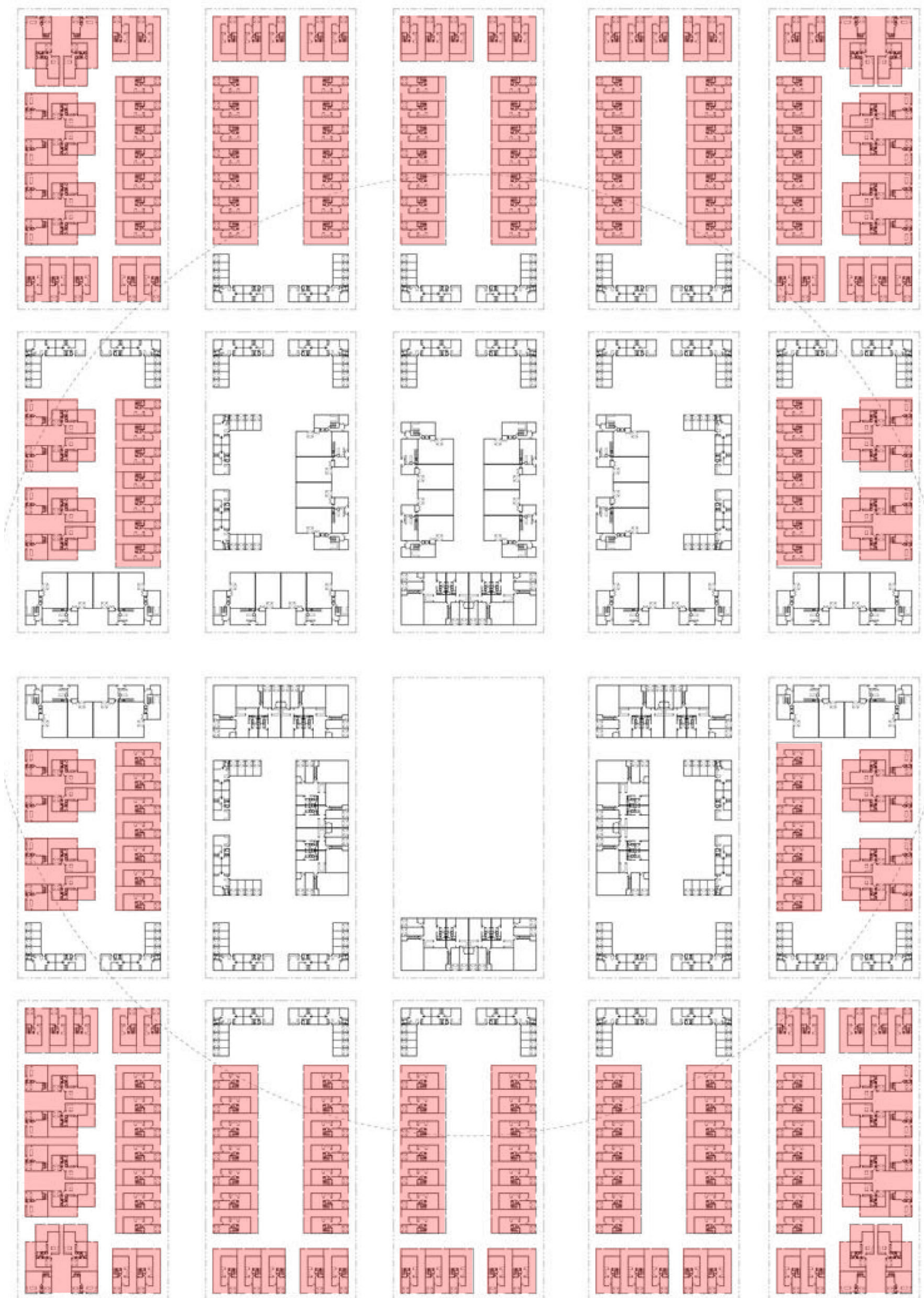


Figure 6.60.
Conceptual Neighborhood diagram
Single Family Housing

The Applied Model

"Observe always that everything is the result of change, and get used to thinking that there is nothing Nature loves so well as to change existing forms and make new ones of them"

Marcus Aurellius

Longmont, CO
image © Lincoln Institute for Land Policy

With the analysis of the individual sustainable block complete, multiple blocks were layed out in a conceptual framework to illustrate that the elements within each block were adaptable block to block to create a community framework. In doing so, without adding other variables such as a neighboring context, the neighborhood composition had a static grid layout quality. To truly become a community, the development layout must respond to other factors, such as context. It was determined that for this reason, as well as to judge whether the model could be applied in a real world situation, to identify a site and apply the model to it.

The existing site.

The Antelope Valley area of California was chosen for a familiarity with California and regional issues within the area. It is one of the outlying desert areas that experienced rapid growth during the building boom, and currently has a significant number of fallow projects. A Google Earth search identified areas with development, and further research identified sites that had enough information to apply the model to. A single site was chosen based on a size small enough to apply the block model to, but large enough to be able to add the community aspects a smaller project would not allow. The actual location of the site chosen will not be identified in this document to prevent any issues with the actual ownership or actual development of the site.

Figure 7.1.
Existing site in various stages of development

The site is approximately 80.9 acres in 4 tracts with a total of 364 single family home lots. The site is rectilinear in shape as are most desert parcels, and is bordered by existing collector

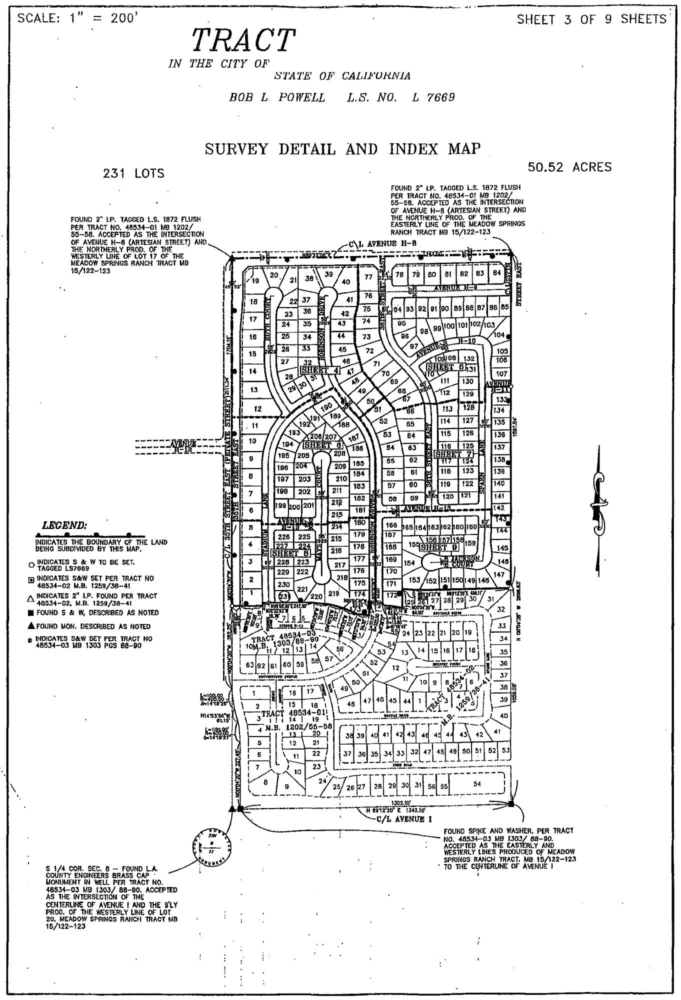


Figure 7.2.

Tract map of the existing site

roads on three sides with a right of way for an additional collector on the fourth side. The site orients directly north, with the longer property lines facing east and west.

An analysis of street patterns shows the typical "loops and lollipops" development pattern. There is a primary vehicular access to the west and to the north, and secondary access to the east. There is no direct access through the site, and it contains 7 cul-de-sacs. The street right of way is 60 feet. It appears to reflect all of the elements seen in the FHA guidelines as well as the ITE street standards described previously in the research. The lots vary in size, and are smaller in the southerly portion of the site than in the northerly portion. All of the houses meet the minimum

Figure 7.3.
Existing site
with houses plotted

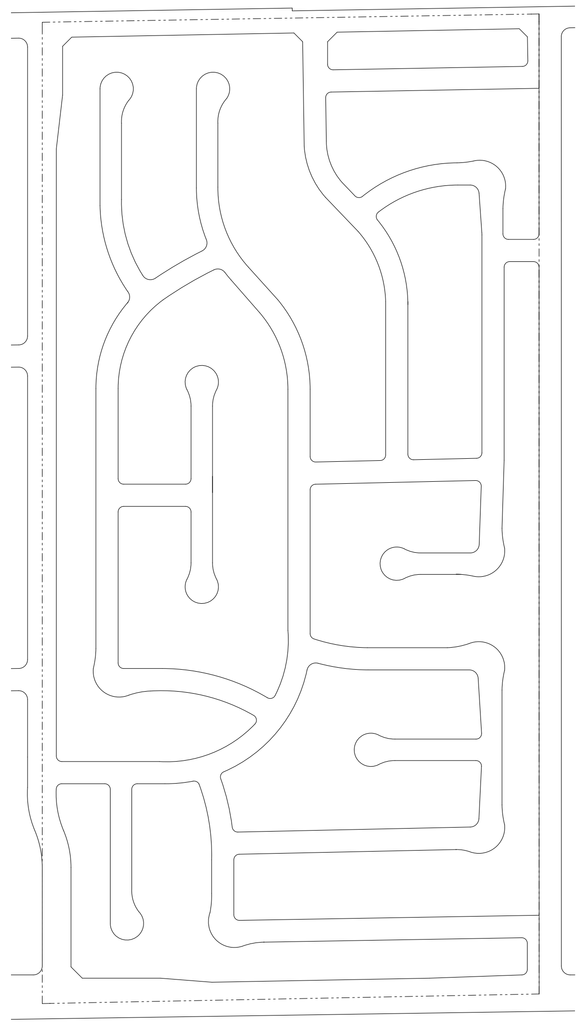


Figure 7.4.
Existing site
Loops and Lollipops
street network

setbacks, and appear to exceed them on most individual home sites. All of the non-built open space is private yards, with the exception of a detention basin on the southeast corner of the site. The location and apparent depth of this basin would indicate that it is not for public use and may actually be fenced off. The site has various stages of development on it, from completed houses, to vacant lots and improved streets. For purposes of this research, the entire site will be analyzed as undeveloped with houses.

Application of the model.

In applying the new model to the site, the concept is to utilize as much of the existing infrastructure as possible. This assumes that as much of the existing street should remain, and that utilities run in the streets. In addition, with a project of this size, there would be a potential to add even more building types to the new model to provide additional housing and business opportunities. The decision was made to use the building types developed in the earlier research and not provide new ones for this portion of the research.

The existing street pattern was analyzed and adjustments were made to reduce the street right of way width and increase connectivity within the context of the existing street pattern. The adapted street system substantially increases inter connectivity to the collector roads as well as internally street to street. A street hierarchy was established as well, providing a main central collector road, secondary streets, and shared streets at cul-de-sac locations. Cul-de-sacs were not eliminated, but the majority were connected with these shared streets, the balance connected to greenspace and via pedestrian connections.

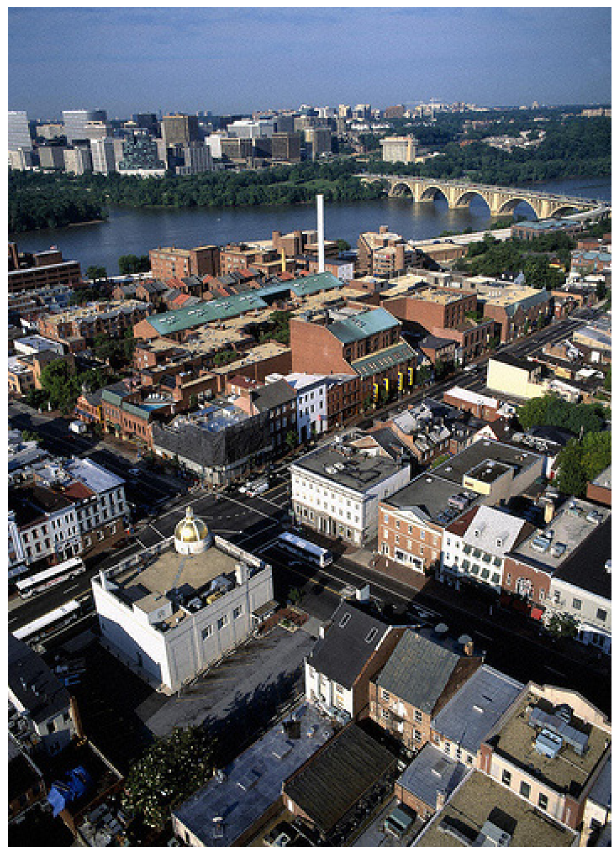


Figure 7.5.

Georgetown, Washington, D.C. often cited as an example of perfect scaled development image © Jason Hawke

Business opportunity buildings, both the multiuse as well as the storefront types were then placed along and adjacent to the central collector. Adjacent to these buildings, apartment blocks were placed, completing the denser "core" area of the community. Single family houses were then placed around the periphery of this core and extending out to the boundaries of the site.

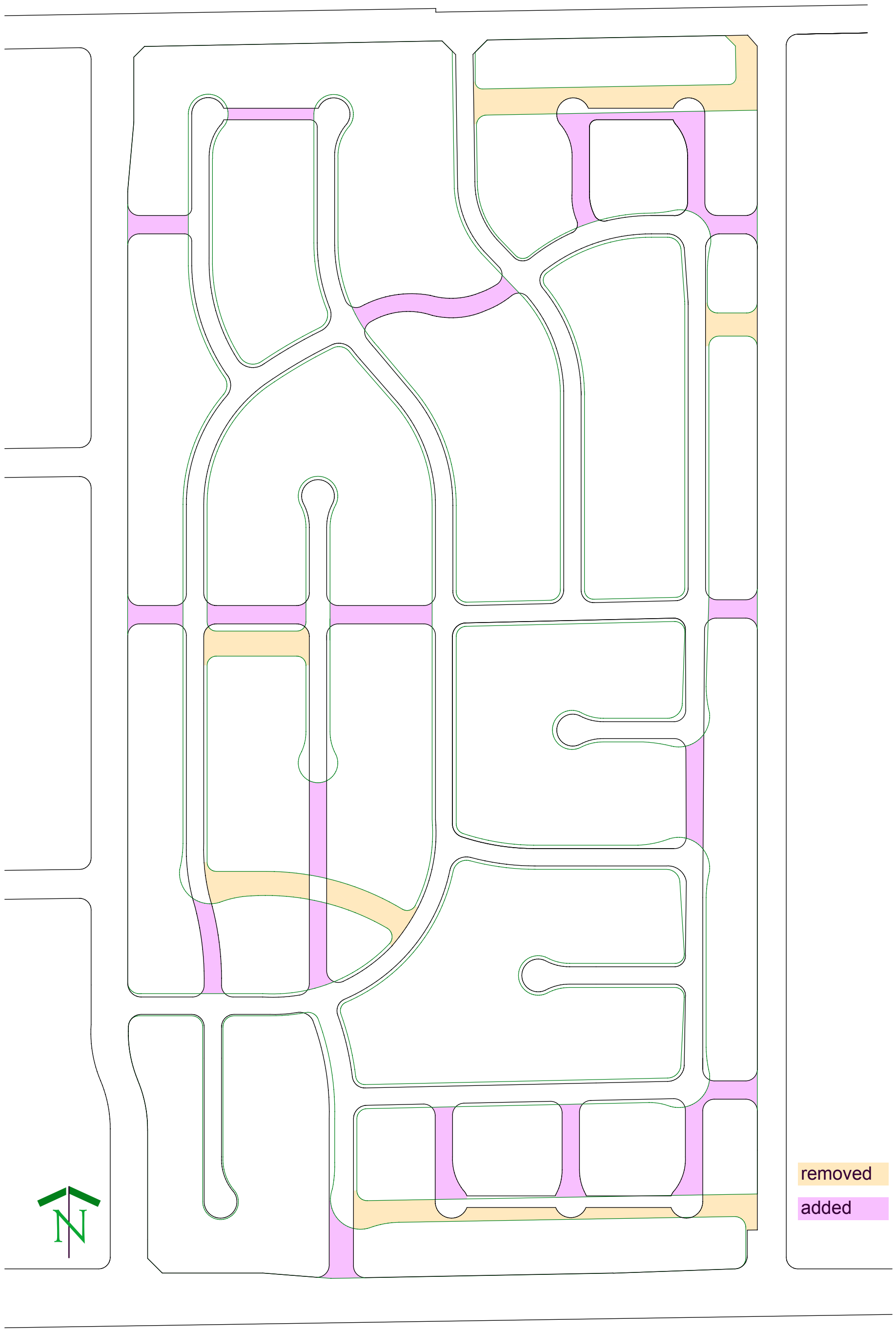


Figure 7.6.

Adjustments to the existing street network. Street sections were added or removed to increase connectivity.

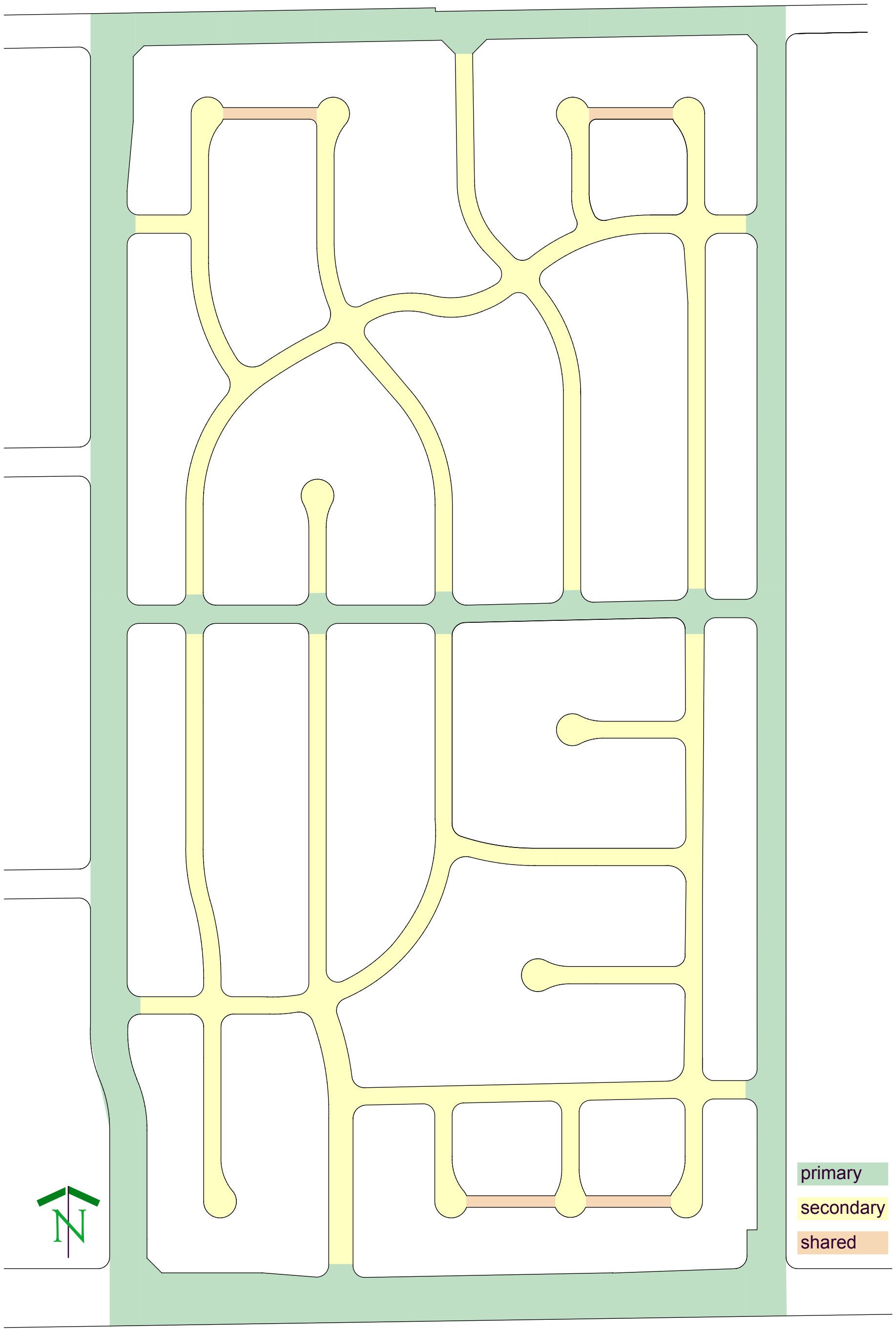


Figure 7.7.
New model street hierarchy, including variable street rights of way and shared streets

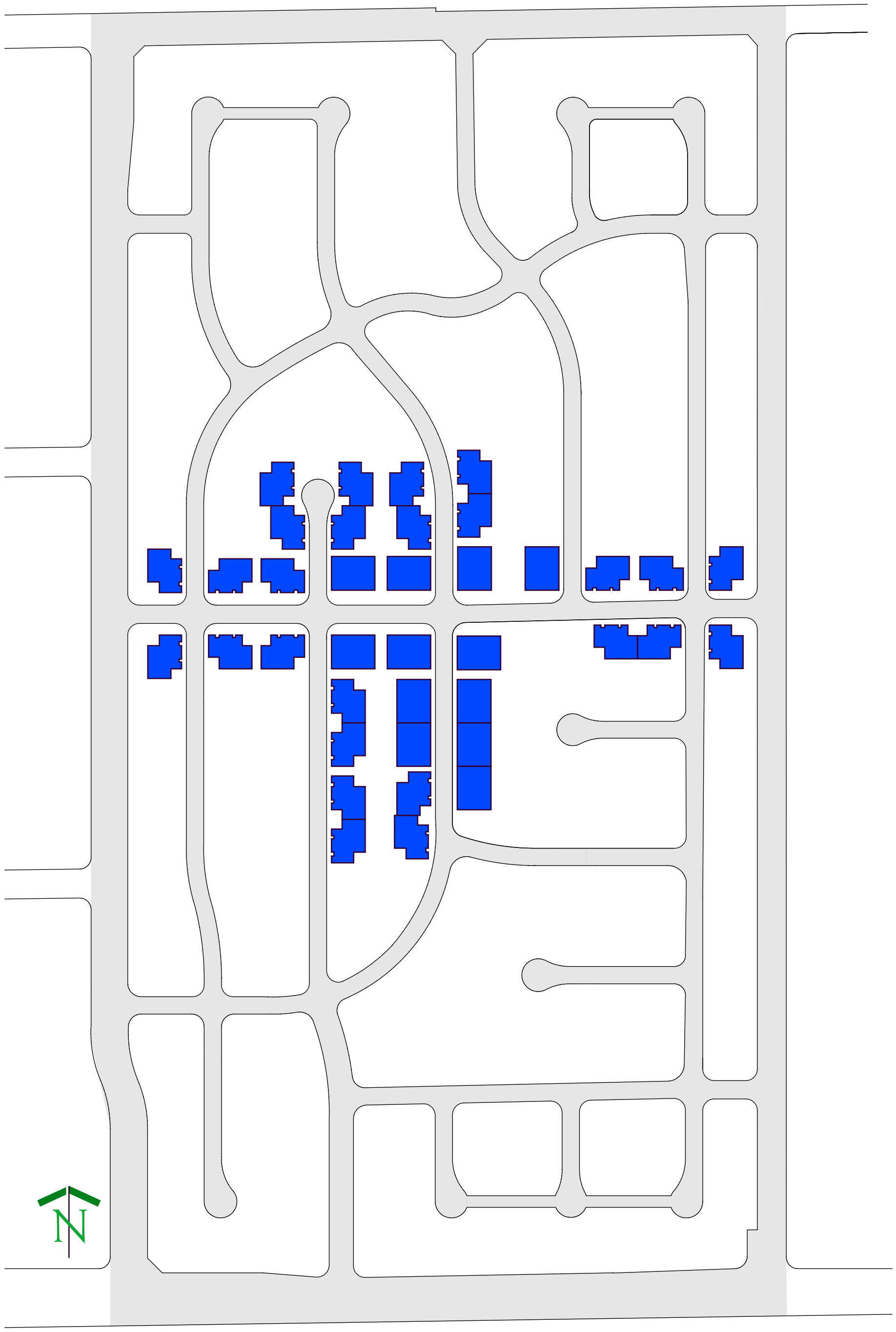


Figure 7.8.
location of Business Opportunity building types

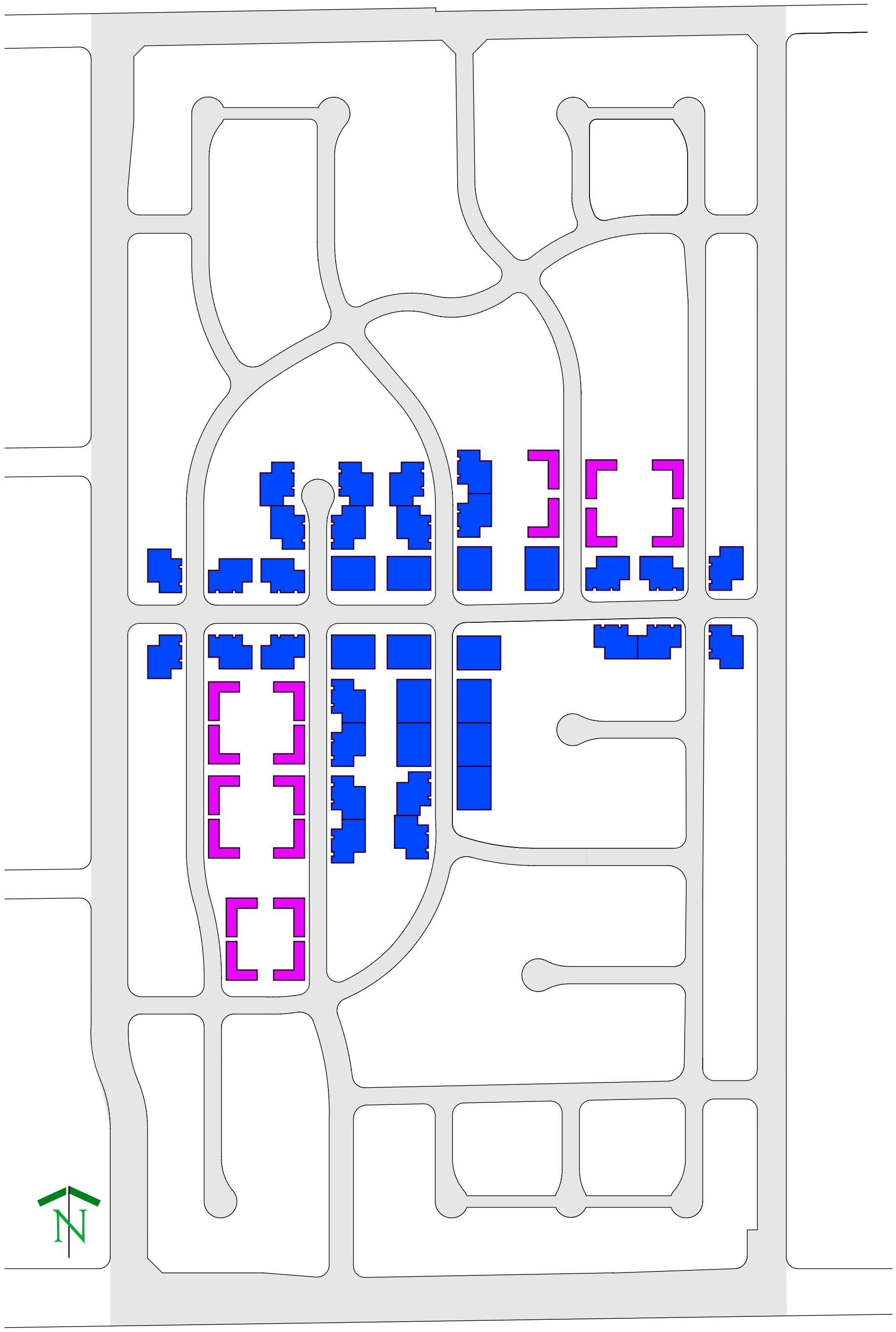


Figure 7.9.
location of Multifamily (apartment and multiuse) housing types

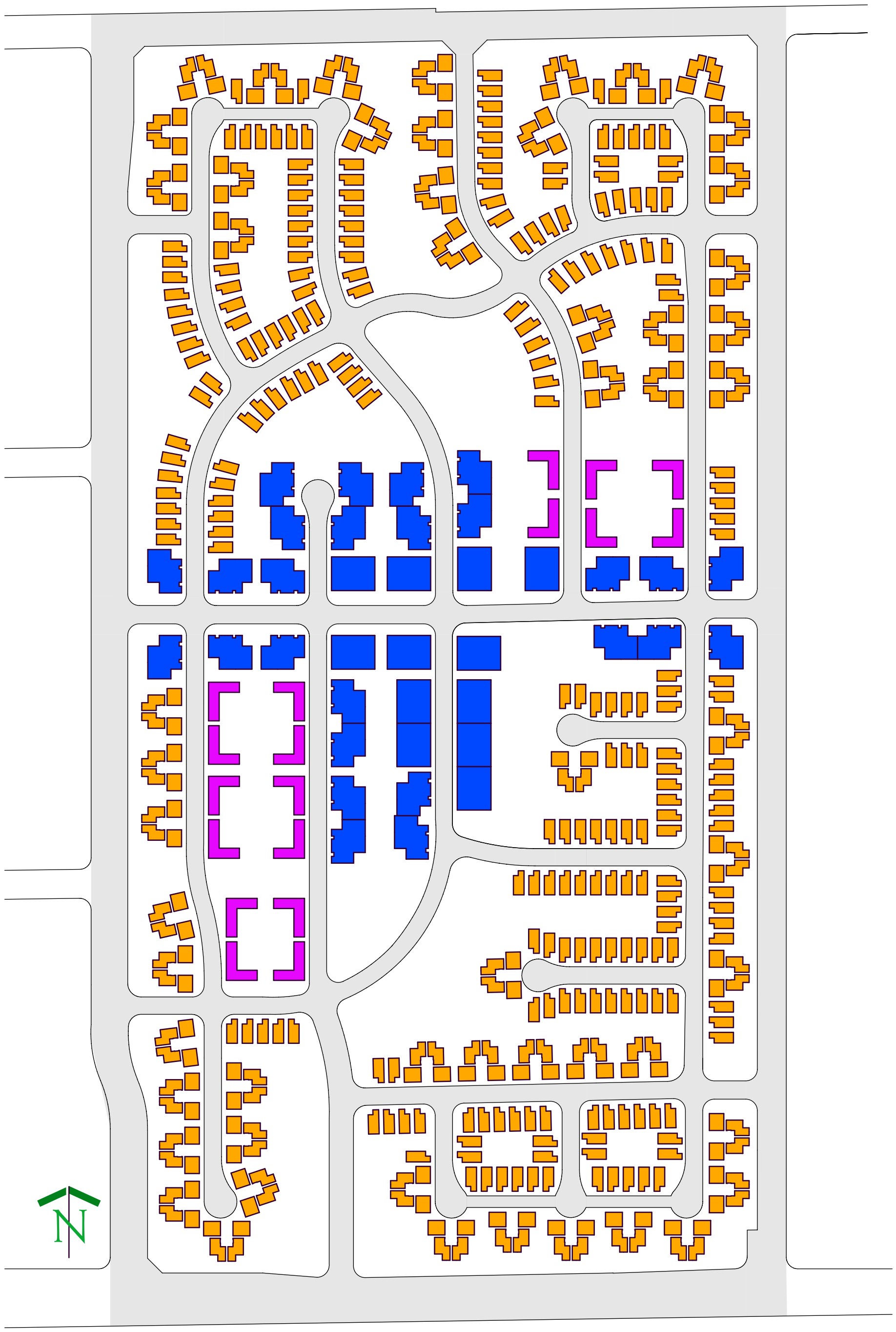


Figure 7.10.
location of all Housing types

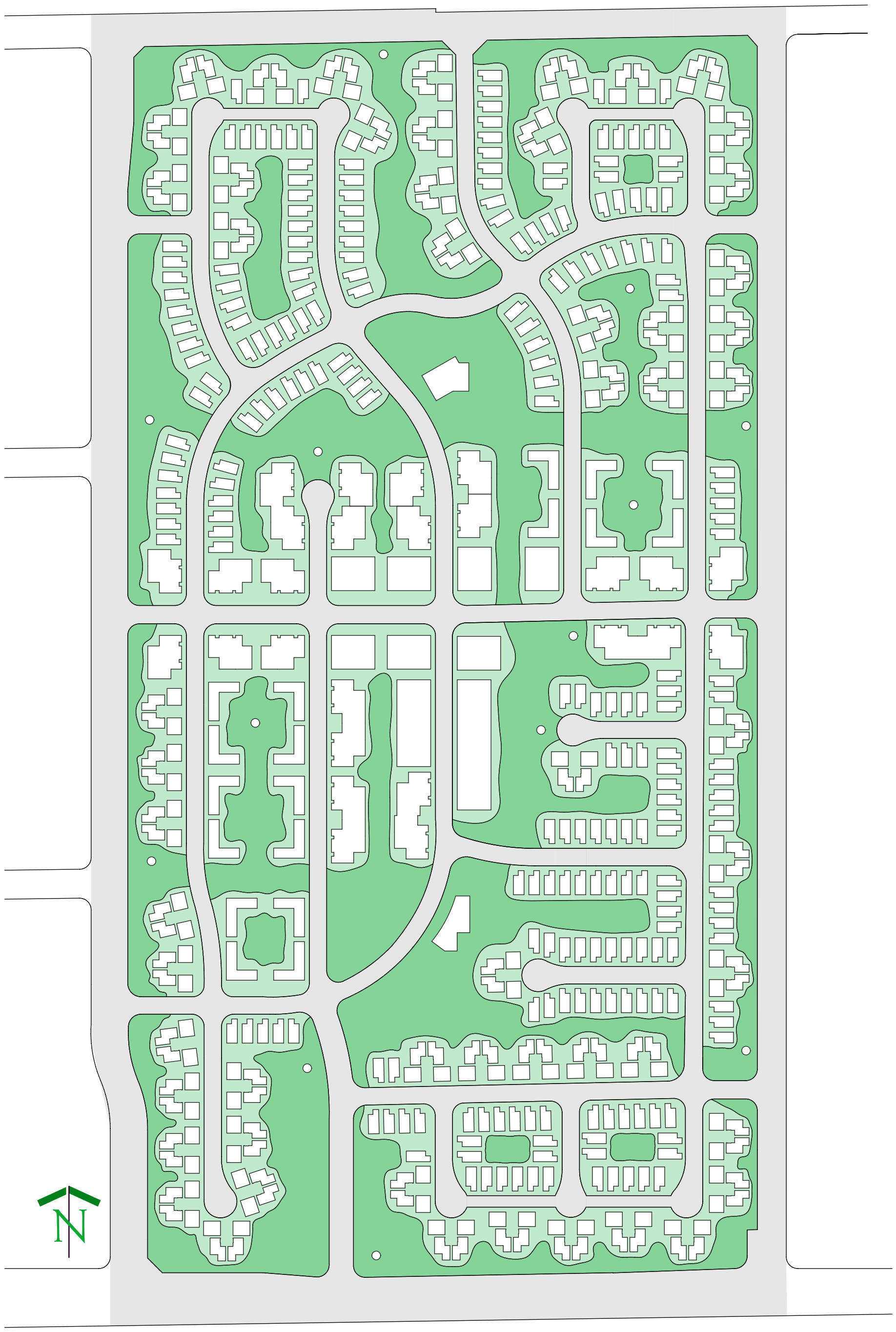


Figure 7.11.
Private and Public greenspace

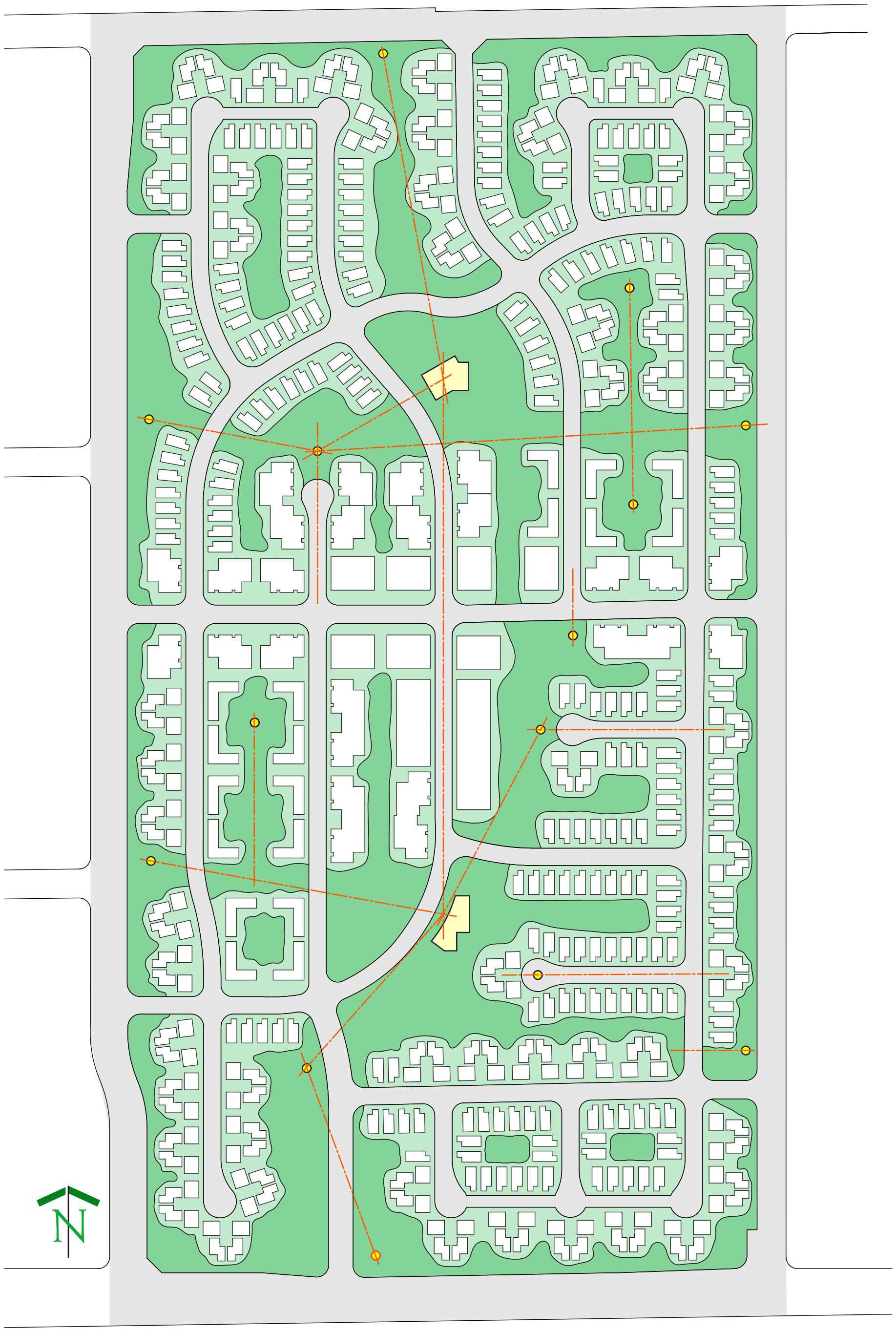


Figure 7.12.

Civic buildings and public pieces

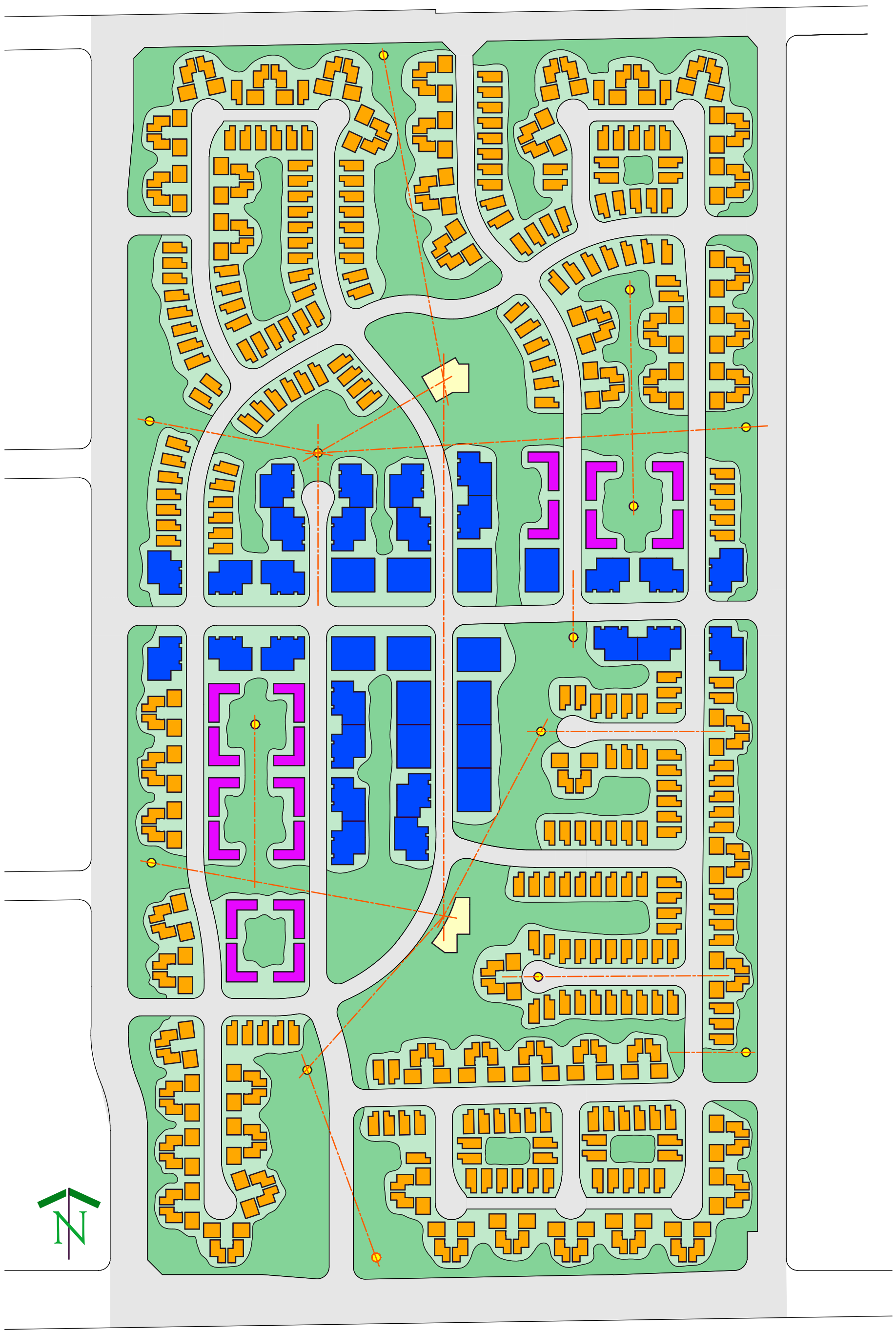


Figure 7.13.

New Model Community Plan

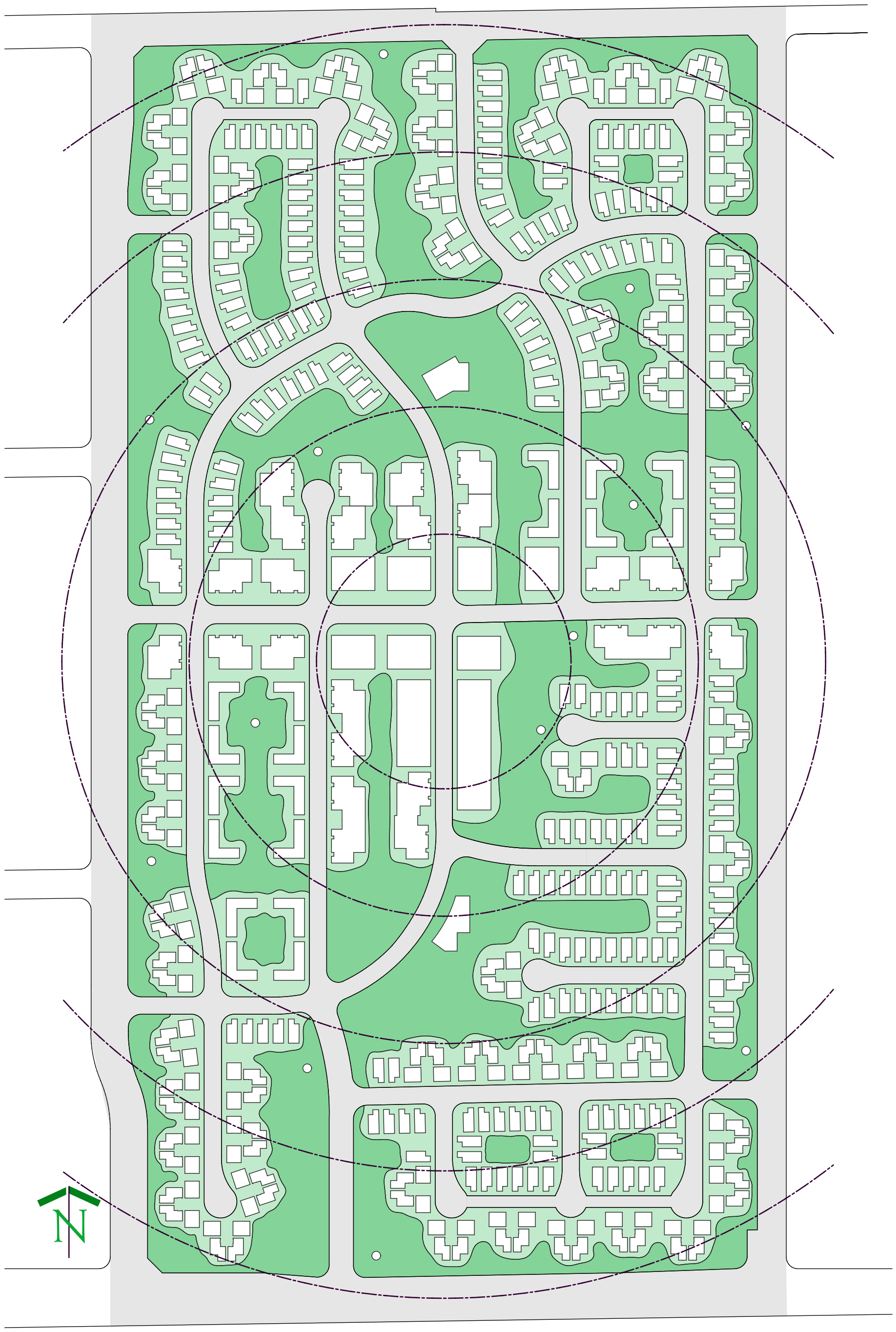


Figure 7.14.

New Model Community Plan with 1-5 minute walking distances

Figure 7.15.

Bridgeport, CT
image ©
Lincoln Institute for Land Policy

Around the buildings, a line demarcating private green space was introduced, and then public green space was added. The entire site was then reviewed for green inter connectivity; for

Figure 7.16.

Camden, NJ
image ©
Lincoln Institute for Land Policy

Figure 7.17.

streetscape
Rouzan, LA
Looney Ricks Kiss Architects

the ability to travel throughout as well as traverse directly across the site via a green open space. Buildings were adjusted as required to accomplish this inter connectivity. Once these elements were identified, various locations for civic icons such as shade structures, artwork, and community buildings were identified. These items, although not discussed within this research, contribute toward the making of memorable places, and thus the making of community.

Figure 7.18.

Contemporary mixed use
San Diego, CA
Jonathan Segal Architects

Figure 7.19.
Common green
Santa Paula, CA
Moule and Polyzoides Architects

Results.

The existing site provided 364 single family homes in a standard suburban layout on 80.9 acres for a density of 4.49 units to the acre. With the new model, 668 units are provided, for a density of 8.25 units to the acre. In addition, 168,000 square feet of multi-use space is provided in incubator type spaces as well as storefront types, with opportunities for offices or retail. With the standard development, there is no common open space, it is all private yard space. Within the new model, each single family unit has private open space, but there is also a combined 21.9 acres of common open space accessible to the entire community. There are more market-desirable cul-de-sacs, but more connectivity within the community as well as to the adjacent communities. With the increased connectivity, ability to walk from anywhere in the community to the central core within 5 minutes, opportunities for neighbor and civic engagement and memorable places, and local services there is truly the opportunity for community to establish within this neighborhood.

Towards true sustainability.

Net Zero Energy. Due to the north/south site direction, the majority of buildings on the site are oriented properly for optimum solar roof exposure, creating the potential for roof integrated Photovoltaic panel placement. The desert environment lends itself well to this application with a high peak sun potential. Because of the location, the potential is also available for wind generated electricity. Integration of these technologies has the potential to drive the form of the individual buildings towards a more site responsive building form beyond the standard builder norm. With the ultimate goal of providing a Zero Net Energy community, the application of energy generation systems should be explored, whether at an individual by-unit basis or a community-based micro utility. A community-common photovoltaic array could double as a outdoor civic shaded space or as shading for a parking

Figure 7.20.
Net Zero Workforce Housing Lopez Island, WA Mithun Architects

lot for electric vehicles. Vertical axis wind turbines could double as light standards and provide common electricity as well. Under current zoning, these items would very likely be not allowed, either too shiny a material in the case of the panels, or too tall in the case of the wind turbines. Of note with this site, there is a large wind farm within twenty miles, so purchase of renewable energy from the utility is also possible if on site generation proved infeasible.

Schools. With the amount of units achievable, the question arises about schooling the children living within the new community, more specifically is there enough students generated in this community to warrant providing a school site. In California, the average Elementary school houses six hundred students on 9.6 acres, Middle school, one thousand students on 21.9 acres, and High school eighteen hundred students on 44.5 acres.[1] For student generation rates, the Irvine Company estimates that it takes 3,169 homes to generate enough students for a new Elementary school, 8,192 for a Middle school and 12,172

Figure 7.21.
Longmont, CO image © Lincoln Institute for Land Policy

new homes for a new High school.[2] For this existing site, the closest Elementary school (with a shared regional park) and Middle school are within a mile of the site. The high school is approximately 3 miles away. Although the Elementary and Middle schools are relatively close by suburban standards, the distance to walk down a pedestrian unfriendly major collector road during the middle of the summer to get to school is probably a remote option.

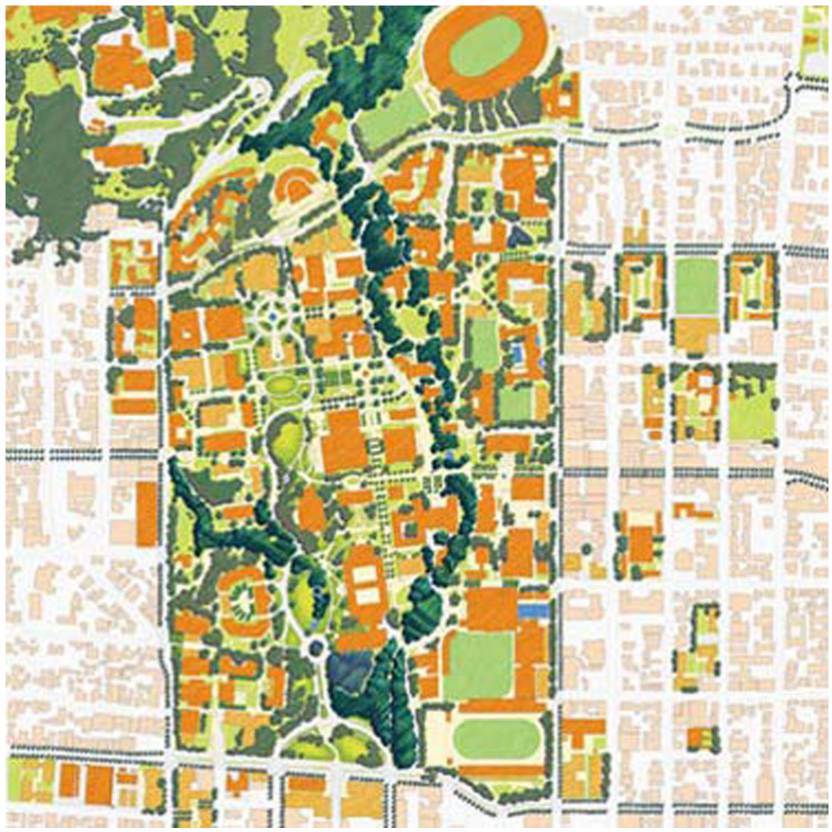
Transportation. As discussed elsewhere in the research, regional connectivity is an issue worth study on its own. The ability to connect to local services and jobs via pedestrian

1. California Department of Education, "School Facilities Facts," http://www.cde.ca.gov/ls/fa/sf/facts.asp.
2. Irvine Company, "Student Generation Rates," http://marketing.irvinecompany.com/entitlement/edu_pa/pa_edu_IRVINE_vFIN.pdf.

connections was one of the drivers of the development plan. It has been suggested though, that there would be the potential for a local transportation shuttle option between communities designed as the new model suggests. With this option, it may be possible to connect from this sustainable neighborhood to the next one, via non-polluting electric vehicles or shared cars. If the adjacent communities develop with the same level of connectivity to this one, the need to use vehicular methods of transportation decreases even more. Because this neighborhood will provide business and service opportunities, there is the ability for the existing adjacent communities to take advantage of these services, further enhancing their economic viability, and potentially further reducing the need for transportation for a wider area.

Figure 7.22.
Seaside, FL
carless housing development
DPZ

CONCLUSIONS



"We do make a difference-one way or another. We are responsible for the impact of our lives. Whatever we do with whatever we have, we leave behind a legacy for those who follow"

Stephen Covey

image © Sasaki Associates

Drivers of the current single family home development type.

The historic actions taken by the Federal Housing Administration (FHA) in the late 1930s created the housing financing and "master developer" models that favor the financing and construction of single family residences. They are the models predominantly in use today. Typically, the construction of single family homes has been perceived as the least risk from a construction financing perspective, helped by federal financing guarantees for this type of housing.

Figure 8.1.
Sun City, AZ

The Institute of Traffic Engineers (ITE) subdivision street standards, based originally on the FHA technical bulletins from 1936 and 1938, are largely responsible for the shape of suburban single family tract development. Although the original standards called for streets to be designed for maximum "livability", the inflexible yet measurable numerical standards that were included within the standards are the basis for most subdivision design today. Because of these standards, it is usually the civil engineer that designs the neighborhood, rather than an interdisciplinary team of engineer, architect, landscape architect, town planner and developer. The paving of streets and development of individual lots increases impermeable surfaces, and the corresponding stormwater runoff is dealt with via the streets and storm drain systems that take this water to streams, lakes and eventually the ocean.

Figure 8.2.
Typical subdivision, somewhere in Florida

The typical suburban single family house remains the preferred housing choice for most Americans. Since the 1950s, it has increased in size and amenities, now in direct contrast with the demographic shifts in our country's population. While the typical nuclear family is no longer the norm, housing is built as if it was. The result is it is taking more housing to shelter our population, and the amount of house per person is at an all-time high. The approval and development of a housing project requires overcoming obstacles, many of which drive up the price of each house. The house in turn must be increased in size (both the lot and the house that sits on it) to justify the sales price which is based on house square footage. As the development progresses, house prices are compared against "comparables", identical houses within similar neighborhoods. Keeping all of the housing within the neighborhood identical provides the comparables and maintains the home values within the neighborhood. This also contributes to the lack of diversity of housing options produced and offered by the developer.

Figure 8.3.
Large Houses on Large Lots, Dallas, TX

Current zoning defines the land use and lot restrictions within a subdivision. To comply with these restrictions results in homogeneous neighborhoods of similar houses. Growth in many areas where these housing projects are located is driven by the necessity to collect developer fees to contribute to the jurisdiction's general fund. The need for the jurisdiction to provide affordable housing typically generates additional fees on the homes a developer is proposing, driving house size up within the development, while the affordable housing gets built in a separate location.

Resource Use Conclusions.

Land Use:

The research has shown that it is possible to significantly increase the density of a given suburban block, while maintaining single family houses as a housing type within the block. Within this block, multiple housing types are achievable together, as well as opportunities for multi-use business spaces. Even with this increase in density, an increase in livable outdoor space is achievable, as well as an increase in pervious surface. This pervious surface translates into ability to reduce the amount of stormwater runoff, lessening the impact on infrastructure and the downstream environment.

Energy Use:

To determine energy usage, it was necessary to tie housing unit energy efficiency to construction cost. The research indicates that, by building an efficient sized housing units, even with a significant increase in density, construction cost is less per housing block. If these units are built to an efficiency level common to two popular green building standards, cost is still less, and energy use decreases dramatically. To build these units to full Zero Energy though increases to cost of the units by over 12 percent above the cost of a standard block, due to the high cost of providing all of the required energy through individual unit-mounted photovoltaic systems. As the cost of these systems decreases, their use should increase, toward the ultimate goal of true Zero Energy sustainable developments.

Water Use:

Because water use is based on building occupants, the new block model, with significantly more occupants, demands more water than the standard suburban block. This changes for interior use with the addition of efficient fixtures and/or grey water use. When combined with exterior landscaping water demand and with the use of xeriscape landscaping watered with grey water through a drip irrigation system, the new block model still achieves a reduced overall water usage as compared with the standard block. For sewer water, the new block model generates less waste water, even more when a grey water system is employed that diverts most of the fluid to the landscaping system. This results in an overall decrease in sewer water of 64 percent.

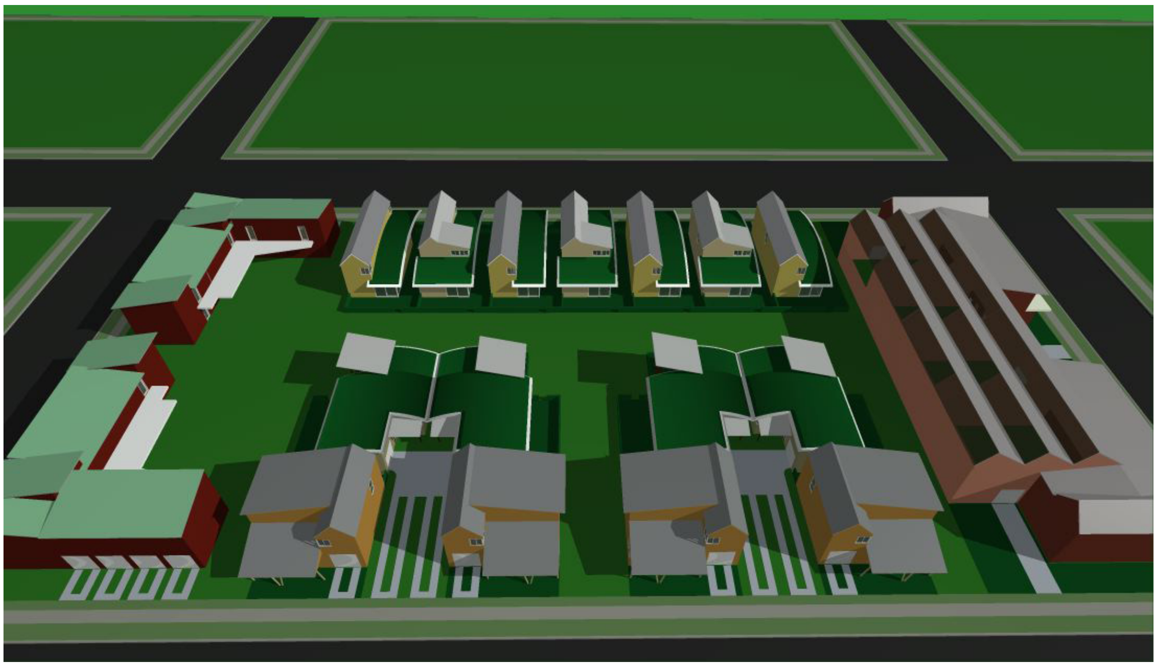


Figure 8.4.

image of block model

Impediments / Opportunities for Implementing the new Model.

Within the drivers of the current single family home development type lie many of the impediments to changing the status quo and developing using the new model. But each of these constraints appears to have a corresponding opportunity to move forward.

Financing:

The financing both for construction and mortgages of single family homes is considered lower risk than other forms of financing, but the current economic issues we are dealing with are based in large part on the mortgage and finance industry and single family mortgages. Most often now it is the case that a given development project will have multiple sources of construction financing to have enough funding to develop the project. To apply this type of thinking to the new model is appropriate, with one difference: the different housing types within the block would be the natural places to have separate construction funding or even permanent financing. The single family housing could be financed with a lender that only does single family lending, the apartments with apartment financing, and the multi-use component with either a mixed-use financing vehicle or even commercial financing. The underlying land development could be undertaken by any of these three, or potentially even a fourth source. This has the potential to lessen the exposure to risk, with different financing from different sectors of the lending industry. It is conceivable also, that these individual housing types could be built by different developers within the same block, lessening an individual builder's exposure to economic downturns.This lessened risk could then potentially translate into the availability of mortgages to housing types other than predominately single family housing.

Street Standards:

As we have seen, national street standards have dominated the design of neighborhoods. Because the standards have measurable values, both the civil engineering community and the governing jurisdictions look to them for common ground. By adhering to the numerical standards of the ITE standards, and not the underlying intent of "livability", streets are for traffic control, not an integral part of the shaping of a community. There are an increasing number of jurisdictions that are modifying their street standards, in many cases because implementing them within existing neighborhoods has proven problematic. There are also jurisdictions incorporating semi-private streets to allow for different widths and configurations than the national standards, while limiting liability exposure to the jurisdiction. It appears here there actually is already the desire and flexibility to redo street standards to make them more community based, and at the same time introduce Woonerf and other shared street concepts. There also appears to be, thanks to the TND design community, enough data regarding safety and access of emergency vehicles on narrower streets. There needs to be the will on both the part of the engineer and the jurisdiction to think in terms of community design as opposed to traffic efficiency. There is also the opportunity now to take a more interdisciplinary approach to neighborhood design. For example, rather than the engineer giving the architect an envelope to plop their houses into, collectively, with a town planner if necessary, lay the streets out based on a logical connected hierarchy of uses. Have the landscape architect lay out a connected framework of greens paces based on the natural features and topography, then lay the community out within and around that framework. It appears time now to reintegrate the design disciplines together with the developer for true integrated community design.

House size and price:

The research shows the size of the average single family house of today, and its historic rise to the brink of the economic downturn. There is a trend, visible through articles now appearing, that there finally may be a decrease in the average house size. The best selling homes today are all relatively small and cost effective to build.[1] Because there is still a demand for housing, there is an opportunity now to take advantage of buyers wanting smaller homes and applying the new model, making these small houses more energy efficient. This also provides the opportunity to reevaluate house pricing based on square footage. The new focus can be on sales price based on neighborhood location and walkability as we have seen elsewhere in this research. This could also lead to discussions of affordability based on overall housing costs, with mortgage payment and utility bills combined, as is common in the affordable housing industry.

Zoning:

Current Euclidean zoning is single use zoning. Within a single family zone, there are density limits, setback requirements, lot size, width and depth requirements, building height limits, and parking requirements. The new development model would not be allowed within a single family housing zone. Two opportunities appear: Many jurisdictions have in place a zone called a Planned Development (PD) zone (often called a PUD, planned unit development)[2]. When a developer proposes a single family home development in a PD zone, the setbacks, density, and street widths are all determined by what the developer proposes, as opposed to the strict application of setbacks and other restrictions. It is conceivable that, within this zone type, additional uses could be proposed (other than strictly single family uses, with limitations for obnoxious uses) as well. The second opportunity would be the application of

1. Jenny Sullivan, “Cottage Industry,” Builder Magazine 2008.

2. Michael Southworth, and Ben-Joseph, Eran, Streets and the Shaping of Towns and Cities (Washington: Island Press, 2003).

a Form Based Code. With this type of code, development is determined by building form, not by use. This particular type of code is becoming popular in jurisdictions where Smart Growth and Traditional Neighborhood Design (TND) are being encouraged. The new development model could be implemented in its current form under this type of code. The downside to this code is that it requires a wholesale replacement of the jurisdiction's Zoning Code, which is typically not an easy task. Both of these opportunities require somewhat of a shift in policy with the jurisdiction. The adjustment of a PD zone to allow neighborhood serving uses may be easier to accomplish.

Green benefits:

Currently the majority of benefits of a greener home are to the consumer, in lower utility bills and tax incentives for installed green components. There are programs in the market place that benefit the builder, but as we have seen in the research, there is usually a substantial price tag for obtaining these benefits. There is an opportunity here to incentivize a builder to develop this type of project. The research has shown that a more efficient development model is achievable. A jurisdiction, looking to develop a project that has multiple housing types, opportunity for affordable housing, and less intense utility burdens may provide incentives for this type of project. These incentives could be reduced permitting fees, a streamlined approval process, less environmental scrutiny, increased density, or even redevelopment funds.

Perhaps the ultimate answer would be a combination of many of these ideas into a comprehensive "Sustainable Suburban Subdivision Code". Within the code would be a combination of restrictions and incentives that may include criteria for: environmental location, form based land use, density minimums, street standards, outdoor on site livable space, public open space, landscaping and shade coverage, building resource use, affordable housing, walkability/bikability, connectivity within the neighborhood and to public transportation, solar orientation, infiltration/biofiltration, business incubation, and micro-utilities among others. This code would have to be adaptable to individual jurisdictions' location, scalable, and have the political will to implement it. The USGBC has introduce a pilot *LEED for Neighborhood Development* (LEED-ND)[3] program that shows some promise in a few of these areas, but it is a voluntary land use model that does not contain the policy changes and developer incentives that will truly be required to make a fundamental change to the existing development model.

Choice:

The single family suburban lifestyle is the lifestyle of the majority of the people in the United States. Given the opportunity, many others would like to be part of that American Dream. But within that dream, there is a small range of options to choose from, and all require a car and substantial energy use. But the reality of the current condition requires a change in thinking from us all, thinking that there is another way to develop housing in a more sustainable way. But as Anthony Flint states, "It is clear that changes in development patterns need to happen within the framework of the free market, within the context of choice and freedom...A new development paradigm isn't going to happen overnight. And when it does, it's going to be driven by personal needs. Where we live and work is an intensely personal choice, and we are not going to make that choice based on what's good for society or what's good for the environment."[4]

The new development model will provide a choice other than to get in a car and drive to wherever we work, shop, and play. It will provide a choice to live where your house is measured not by the square foot, but by how well it provides personal indoor and outdoor living space, and measured not by the size of its neighbors but by its

3. USGBC, "Leed for Neighborhood Development," (2009).

4. Anthony Flint, This Land : The Battle over Sprawl and the Future of America (Baltimore: Johns Hopkins University Press, 2006).

location within a desirable walkable green neighborhood. It will provide a choice of a slightly higher mortgage in exchange for no utility bills and a promise of resource availability for your children. By providing this choice, the population may chose to live in a way that accommodates their needs, provides a sense of community beyond what they experience now, and protects the environment at the same time. And when they do, the cities will choose to allow and encourage this type of development, and the developers of housing will choose to provide it to the population that asks for this new type of housing.

The research has proven that a new development model is possible. The impediments to shifting to this new development model are not insurmountable, and appear to be achievable with incremental changes to the way the current development pattern is designed, approved, financed and built. The benefits to the developer are an increase in the number of housing units they can build within a given plot of land in a cost effective manner, and the ability to get back to building housing in the current economy. The benefits to the jurisdiction are the ability to provide affordable housing, continue to grow while increasing their tax base with small businesses, and do so without having to provide more infrastructure. The benefits to the homeowner are increased livability, decreased car use, and affordable housing costs within a mixed neighborhood of green space, neighborhood services and housing. The benefits to all are the accommodation of inevitable growth and the achievement of the American Dream, while diminishing the use of our precious natural resources.

Suburbia can become sustainable.

Potential Areas of Additional Study.

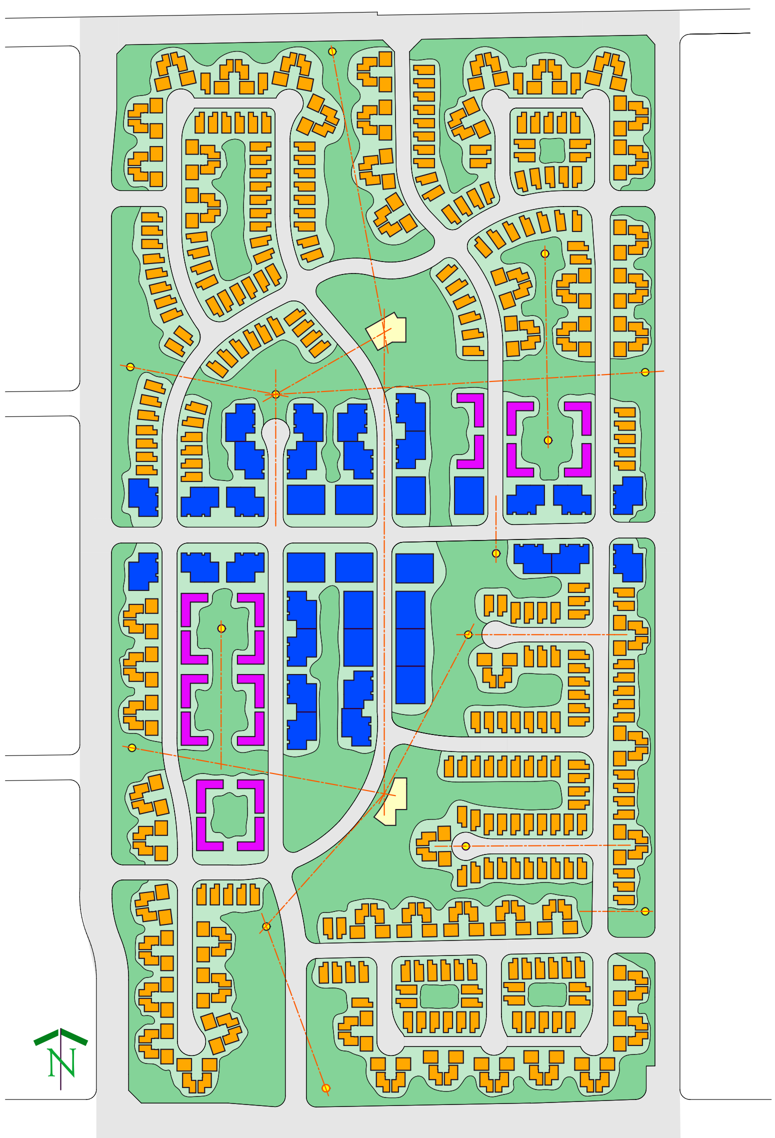
Adaptation of this block concept to a regional setting to include a transportation system. To do so would most likely require a site specific response, to gauge availability of bus, light rail, or other transportation modes, as well as intensity and size of the neighborhoods to support such a transportation system.

Economic evaluation of the business opportunities within the model. These would include determining neighborhood size to optimize profitability, capture rates, pass through and tax structures. Falling within this realm could also be construction and permanent financing of these types of communities and redevelopment opportunities.

Adapting micro-utility concepts to the model. There might be the opportunity to develop block sized utilities, such as a micro-electric grid based on wind or solar, micro-heat or cooling through a common ground loop heat pump system, or a micro-sewage treatment facility. These would most likely require a site specific response as well, to determine wind speeds, solar orientation, soils types and other necessary data to determine their applicability and effectiveness.

Marketing studies that ask different questions about new housing opportunities. Currently there are predominantly two different types of surveys: census data of individuals, and home builder driven data of home builders themselves or market preference surveys. Developers of single family homes rely heavily on these surveys to determine what to build. The responses though, are specific to the information being asked and what the questioner is looking for. Market studies could be tailored to "cast a wider net" about living preferences in neighborhoods and about green concepts and sustainability within people's living arrangements.

The creation of a model Sustainable Suburban Subdivision Code. To accomplish this would require locating the code within a state to look into current subdivision and redevelopment law, liability issues, energy efficiency and building codes, public policy and tax incentives. There are the beginnings of codes that deal with energy efficiency and city planning, but to date these are more often related to commercial or mixed use building types within urban centers. There is the potential to adapt applicable concepts and language from these often single subject codes into a more comprehensive model to deal with the suburban condition.



Appendix 1. LEED-ND Pilot Checklist.

LEED for Neighborhood Development Pilot
Draft Project Checklist

Project Name: ______________________

Project City: ______________ Project State: ________

***Note**: Registration for the LEED for Neighborhood Development Pilot Program is closed; registration for the fully launched program is planned to open in late 2009, pending USGBC member ballot approval.

Yes	?	No	Project Totals (Pre-Certification Estimates)		106 Points
			Certified: 40-49 points **Silver**: 50-59 points	**Gold**: 60-79 points	**Platinum**: 80-106 points

Yes	?	No	Smart Location & Linkage		30 Points
Yes			Prereq 1	**Smart Location**	Required
Yes			Prereq 2	**Proximity to Water and Wastewater Infrastructure**	Required
Yes			Prereq 3	**Imperiled Species and Ecological Communities**	Required
Yes			Prereq 4	**Wetland and Water Body Conservation**	Required
Yes			Prereq 5	**Farmland Conservation**	Required
Yes			Prereq 6	**Floodplain Avoidance**	Required
			Credit 1	**Brownfield Redevelopment**	2
			Credit 2	**High Priority Brownfields Redevelopment**	1
			Credit 3	**Preferred Location**	10
			Credit 4	**Reduced Automobile Dependence**	8
			Credit 5	**Bicycle Network**	1
			Credit 6	**Housing and Jobs Proximity**	3
			Credit 7	**School Proximity**	1
			Credit 8	**Steep Slope Protection**	1
			Credit 9	**Site Design for Habitat or Wetlands Conservation**	1
			Credit 10	**Restoration of Habitat or Wetlands**	1
			Credit 11	**Conservation Management of Habitat or Wetlands**	1

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LEED for Neighborhood Development Pilot
Draft Project Checklist

Yes	?	No	Neighborhood Pattern & Design		39 Points
Yes			Prereq 1	**Open Community**	Required
Yes			Prereq 2	**Compact Development**	Required
			Credit 1	**Compact Development**	7
			Credit 2	**Diversity of Uses**	4
			Credit 3	**Diversity of Housing Types**	3
			Credit 4	**Affordable Rental Housing**	2
			Credit 5	**Affordable For-Sale Housing**	2
			Credit 6	**Reduced Parking Footprint**	2
			Credit 7	**Walkable Streets**	8
			Credit 8	**Street Network**	2
			Credit 9	**Transit Facilities**	1
			Credit 10	**Transportation Demand Management**	2
			Credit 11	**Access to Surrounding Vicinity**	1
			Credit 12	**Access to Public Spaces**	1
			Credit 13	**Access to Active Public Spaces**	1
			Credit 14	**Universal Accessibility**	1
			Credit 15	**Community Outreach and Involvement**	1
			Credit 16	**Local Food Production**	1

LEED for Neighborhood Development Pilot
Draft Project Checklist

Yes	?	No	Green Construction & Technology		31 Points
Yes			Prereq 1	**Construction Activity Pollution Prevention**	Required
			Credit 1	**LEED Certified Green Buildings**	3
			Credit 2	**Energy Efficiency in Buildings**	3
			Credit 3	**Reduced Water Use**	3
			Credit 4	**Building Reuse and Adaptive Reuse**	2
			Credit 5	**Reuse of Historic Buildings**	1
			Credit 6	**Minimize Site Disturbance through Site Design**	1
			Credit 7	**Minimize Site Disturbance during Construction**	1
			Credit 8	**Contaminant Reduction in Brownfields Remediation**	1
			Credit 9	**Stormwater Management**	5
			Credit 10	**Heat Island Reduction**	1
			Credit 11	**Solar Orientation**	1
			Credit 12	**On-Site Energy Generation**	1
			Credit 13	**On-Site Renewable Energy Sources**	1
			Credit 14	**District Heating & Cooling**	1
			Credit 15	**Infrastructure Energy Efficiency**	1
			Credit 16	**Wastewater Management**	1
			Credit 17	**Recycled Content for Infrastructure**	1
			Credit 18	**Construction Waste Management**	1
			Credit 19	**Comprehensive Waste Management**	1
			Credit 20	**Light Pollution Reduction**	1

Yes	?	No	Innovation & Design Process		5 Points
			Credit 1.1	**Innovation in Design:** Provide Specific Title	1
			Credit 1.2	**Innovation in Design:** Provide Specific Title	1
			Credit 1.3	**Innovation in Design:** Provide Specific Title	1
			Credit 1.4	**Innovation in Design:** Provide Specific Title	1
			Credit 1.5	**Innovation in Design:** Provide Specific Title	1
			Credit 2	**LEED® Accredited Professional**	1

Appendix 2. LEED-H Checklist.

for Homes

Project Checklist

LEED for Homes

Builder Name:	
Responsible Party (if different):	
Home Address (Street/City/State):	

Input Values: *Click here if you're experiencing problems*
No of Bedrooms: 4 Floor Area (SF): 2400

Minimum No. of Points Required:
Certified: 45 Silver: 60 Gold: 75 Platinum: 90

Detailed information on the measures below are provided in the companion document "LEED for Homes Rating System" ***Max Points Available***

Y / Pts	No	N/A	#	Credit	Measure		Max Points
				Innovation and Design Process (ID)	(Minimum of 0 ID Points Required)		**9**
			1.1	**Integrated Project Planning**	Preliminary Rating		Prerequisite
			1.2		Integrated Project Team		1
			1.3		Design Charrette		1
			2.1	**Quality Management for Durability**	Durability Planning; (Pre-Construction)		Prerequisite
			2.2		Wet Room Measures		Prerequisite
			2.3		Quality Management		Prerequisite
			2.4		Third-Party Durability Inspection		3
			3.1	**Innovative / Regional Design**	Provide Description and Justification for Specific Measure		1
			3.2		Provide Description and Justification for Specific Measure		1
			3.3		Provide Description and Justification for Specific Measure		1
			3.4		Provide Description and Justification for Specific Measure		1
0				Sub-Total			
				Location and Linkages (LL)	(Minimum of 0 LL Points Required)	OR	**10**
			1	**LEED-ND Neighborhood**		**LL2-5**	10
			2	**Site Selection**	Avoid Environmentally Sensitive Sites and Farmland	**LL1**	2
			3.1	***Preferred Locations***	Select an Edge Development Site	**LL1**	1
			3.2		***OR*** Select an Infill Site	**LL1**	2
			3.3		Select a Previously Developed Site	**LL1**	1
			4	**Infrastructure**	Site within 1/2 Mile of Existing Water and Sewer	**LL1**	1
			5.1	**Community Resources & Public Transit**	Basic Community Resources / Public Transportation	**LL1**	1
			5.2		***OR*** Extensive Community Resources / Public Transportation	**LL1**	2
			5.3		***OR*** Outstanding Community Resources / Public Transportation	**LL1**	3
			6	***Access to Open Space***	Publicly Accessible Green Spaces	**LL1**	1
0				Sub-Total			
				Sustainable Sites (SS)	(Minimum of 5 SS Points Required)	OR	**21**
			1.1	**Site Stewardship**	Erosion Controls (During Construction)		Prerequisite
			1.2		Minimize Disturbed Area of Site		1
			2.1	**Landscaping**	No Invasive Plants		Prerequisite
			2.2		Basic Landscaping Design		2
			2.3		Limit Turf		3
			2.4		Drought Tolerant Plants		2
			3	**Shading of Hardscapes**	Locate and Plant Trees to Shade Hardscapes		1
			4.1	**Surface Water Management**	Design Permeable Site		4
			4.2		Permanent Erosion Controls / Professional Design of Erosion Control		2
			5	**Non-Toxic Pest Control**	Select Insect and Pest Control Alternatives from List		2
			6.1	**Compact Development**	Average Housing Density ≥ 7 Units / Acre	**LL1**	2
			6.1		***OR*** Average Housing Density ≥ 10 Units / Acre	**LL1**	3
			6.3		***OR*** Average Housing Density ≥ 20 Units / Acre	**LL1**	4
0				Sub-Total			
				Water Efficiency (WE)	(Minimum of 3 WE Points Required)	OR	**15**
			1.1	**Water Reuse**	Rainwater Harvesting System		4
			1.2		Grey Water Re-Use System		1
			2.1	**Irrigation System**	Select High Efficiency Measures from List		3
			2.2		Third Party Verification		1
			2.3		***OR*** Install Landscape Designed by Licensed or Certified Professional	**WE 2.2**	4
			3.1	**Indoor Water Use**	High Efficiency Fixtures (Toilets, Showers, and Faucets)		3
			3.2		**OR** Very High Efficiency Fixtures (Toilets, Showers, and Faucets)	**WE 3.1**	6
0				Sub-Total			

Project Checklist (cont'd)

HERS Index Value Achieved: 85
IECC Climate Zone: 1
EA 1.2 Pts Achieved: 0.0

Y / Pts	No	N/A		Credit	Requirement		Points
				Energy and Atmosphere (EA)	(Minimum of 0 EA Points Required)	OR	**38**
			1.1	**ENERGY STAR Home**	Meets Performance Requirements of ENERGY STAR for Homes		Prerequisite
			1.2		Exceeds Performance of ENERGY STAR for Homes	**EA 2-10**	34
			7.1	**Water Heating**	Improved Hot Water Distribution System		2
			7.2		Pipe Insulation		1
			11	**Refrigerant Management**	Minimize Ozone Depletion and Global Warming Contributions		1
0				Sub-Total (or Sub-Total from Adendum A - Prescriptive EA Credits)			
				Materials and Resources (MR)	(Minimum of 2 MR Points Required)		**14**
			1.1	**Material Efficient Framing**	Overall Waste Factor for Framing Order Shall be No More than 10%.		Prerequisite
			1.2		Advanced Framing Techniques		3
			1.3	***OR***	Structurally Insulated Panels	**MR 1.2**	2
			2.1	**Environmentally Preferable**	Tropical Woods, if Used, Must be FSC		Prerequisite
			2.2	**Products**	Select Environmentally Preferable Products from List		8
			3.1	**Waste Management**	Document Overall Rate of Diversion		Prerequisite
			3.2		Reduce Waste Sent to Landfill by 25% to 100%		3
0				Sub-Total			
				Indoor Environmental Quality (IEQ)	(Minimum of 6 IEQ Points Required)	OR	**20**
			1	**ENERGY STAR with IAP**	Meets ENERGY STAR w/ Indoor Air Package (IAP)	**IEQ2-10**	11
			2.1	**Combustion Venting**	Space Heating & DHW Equip w/ Closed/Power-Exhaust	**IEQ 1**	Prerequisite
			2.2		Install High Performance Fireplace	**IEQ 1**	2
			3	**Moisture Control**	Analyze Moisture Loads AND Install Central System (if Needed)	**IEQ 1**	1
			4.1	**Outdoor Air Ventilation**	Meets ASHRAE Std 62.2	**IEQ 1**	Prerequisite
			4.2		Dedicated Outdoor Air System (w/ Heat Recovery)	**IEQ 1**	2
			4.3		Third-Party Testing of Outdoor Air Flow Rate into Home		1
			5.1	**Local Exhaust**	Meets ASHRAE Std 62.2	**IEQ 1**	Prerequisite
			5.2		Timer / Automatic Controls for Bathroom Exhaust Fans	**IEQ 1**	1
			5.3		Third-Party Testing of Exhaust Air Flow Rate Out of Home		1
			6.1	**Supply Air Distribution**	Perform Duct Design Calculations	**IEQ 1**	Prerequisite
			6.2		Third-Party Testing of Supply Air Flow into Each Room in Home		2
			7.1	**Supply Air Filtering**	≥ 8 MERV Filters, w/ Adequate System Air Flow	**IEQ 1**	Prerequisite
			7.2	***OR***	≥ 10 MERV Filters, w/ Adequate System Air Flow		1
			7.3	***OR***	≥ 13 MERV Filters, w/ Adequate System Air Flow		2
			8.1	**Contaminant Control**	Seal-Off Ducts During Construction	**IEQ 1**	1
			8.2		Permanent Walk-Off Mats *OR* Shoe Storage *OR* Central Vacuum		2
			8.3		Flush Home Continuously for 1 Week with Windows Open		1
			9.1	**Radon Protection**	Install Radon Resistant Construction if Home is in EPA Zone 1	**IEQ 1**	Prerequisite
			9.2		Install Radon Resistant Construction if Home is not in EPA Zone 1	**IEQ 1**	1
			10.1	**Garage Pollutant Protection**	No Air Handling Equipment OR Return Ducts in Garage	**IEQ 1**	Prerequisite
			10.2		Tightly Seal Shared Surfaces between Garage and Home	**IEQ 1**	2
			10.3		Exhaust Fan in Garage		1
			10.4	***OR***	Detached Garage or No Garage	**IEQ 1**	3
0				Sub-Total			
				Awareness and Education (AE)	(Minimum of 0 AE Points Required)		**3**
			1.1	**Education for Homeowner**	Basic Occupant's Manual and Walkthrough of LEED Home		Prerequisite
			1.2	**and/or Tenants**	Comprehensive Occupant's Manual and Multiple Walkthroughs / Trainings		1
			1.3		Public Awareness of LEED Home		1
			2.1	**Education for Building Mgrs**	Basic Building Manager's Manual and Walkthrough of LEED Home		1
0				Sub-Total			
0				**Project Totals** (pre-certification estimates)	*Estimated Performance Tier:*		***130***

for Homes

Project Checklist, Addendum A

Prescriptive Approach for Energy and Atmosphere (EA) Credits

Detailed information on the measures below are provided in the companion document "LEED for Homes Rating System"

Y / Pts	No	N/A		Energy and Atmosphere (EA)	(Minimum of 0 EA Points Required)	OR	Max Points Available 38
			2.1	**Insulation**	Third-Party Inspection of Insulation, At Least HERS Grade II	**EA 1**	Prerequisite
			2.2		Third-Party Inspection of Insulation, Grade I AND 5% above code	**EA 1**	2
			3.1	**Air Infiltration**	Third-Party Envelope Air Leakage Tested </= 7.0 ACH50 (CZ 1-2)	**EA 1**	Prerequisite
			3.2		Third-Party Envelope Air Leakage Tested </= 5.0 ACH50 (CZ 1-2)	**EA 1**	2
			3.3		***OR*** Third-Party Envelope Air Leakage Tested </= 3.0 ACH50	**EA 1**	3
			4.1	**Windows**	Windows Meet ENERGY STAR for Windows (See Table)	**EA 1**	Prerequisite
			4.2		Windows Exceed ENERGY STAR for Windows (See Table)	**EA 1**	2
			4.3		***OR*** Windows Exceed ENERGY STAR for Windows (See Table)	**EA 1**	3
			5.1	**Duct Tightness**	Third-Party Duct Leakage Tested </= 4.0 CFM25 / 100 SF to Outside	**EA 1**	Prerequisite
			5.2		Third-Party Duct Leakage Tested </= 3.0 CFM25 / 100 SF to Outside	**EA 1**	2
			5.3		***OR*** Third-Party Duct Leakage Tested </= 1.0 CFM25 / 100 SF to Outside	**EA 1**	3
			6.1	**Space Heating and Cooling**	Meets ENERGY STAR for HVAC w/ Manual J & refrigerant charge test	**EA 1**	Prerequisite
			6.2		HVAC is Better than ENERGY STAR	**EA 1**	2
			6.3		***OR*** HVAC Substantially Exceeds ENERGY STAR	**EA 1**	4
			7.1	**Water Heating**	Improved Hot Water Distribution System		2
			7.2		Pipe Insulation		1
			7.3	**Water Heating**	Improved Water Heating Equipment	**EA 1**	3
			8.1	**Lighting**	Install at Least Three ENERGY STAR labeled Light Fixtures (or CFLS)	**EA 1**	Prerequisite
			8.2		Energy Efficient Fixtures and Controls	**EA 1**	2
			8.3		***OR*** ENERGY STAR Advanced Lighting Package	**EA 1**	3
			9.1	**Appliances**	Select Appliances from List	**EA 1**	2
			9.2		Very Efficient Clothes Washer (MEF > 1.8, *AND* WF< 5.5)	**EA 1**	1
			10	**Renewable Energy**	Renewable Electric Generation System (1 Point / 5% Reduction)	**EA 1**	10
			11	**Refrigerant Management**	Minimize Ozone Depletion and Global Warming Contributions		1
0				Sub-Total			

By affixing my signature below, the undersigned does hereby declare and affirm to the USGBC that the LEED for Homes requirements, as specified in the LEED for Homes Rating System, have been met for the indicated credits and will, if audited, provide the necessary supporting documents.

Responsible Party's Name ______ Company ______

Signature ______ Date ______

By affixing my signature below, the undersigned does hereby declare and affirm to the USGBC that the required inspections and performance testing for the LEED for Homes requirements, as specified in the LEED for Homes Rating System, have been completed, and will provide the project documentation file, if requested.

Rater's Name ______ Company ______

Signature ______ Date ______

By affixing my signature below, the undersigned does hereby declare and affirm to the USGBC that the required inspections and performance testing for the LEED for Homes requirements, as specified in the LEED for Homes Rating System, have been completed, and will provide the project documentation file, if requested.

Provider's Name ______ Company ______

Signature ______ Date ______

Appendix 3. NAHB Green Checklist.

There's More to NAHB Green.

This checklist is only a summary and omits pertinent information related to compliance and verification. Further information about the intent of the prescriptions herein and how they are verified for certification purposes can be found at nahbgreen.org. Any questions related to compliance should be directed to your chosen certification verifier or the NAHB Research Center.

Using the online version of this scoring tool at nahbgreen.org as a guide, a builder can request the home receive National Green Building Certification from the NAHB Research Center. The home must be inspected at close-in and when it is finished to verify that the green features chosen are in place.

The Research Center provides local verifier training and accreditation to ensure that certification is consistent, accurate, neutral, and technically rigorous throughout the country.

NAHB Green also includes marketing and advocacy guidance for members and local home building associations to communicate the benefits of green building and the importance of keeping these innovative practices voluntary. HBAs can affiliate with NAHB Green in addition to maintaining current local or regional certifications.

Learn more at
www.nahbgreen.org

It's green building, priced right.

NAHB
NATIONAL ASSOCIATION
OF HOME BUILDERS

1201 15th Street, NW, Washington, DC 20005
800.368.5242 • www.nahbgreen.org

NAHB Model Green Home Building Guidelines Checklist

The NAHB National Green Building Program helps any builder, anywhere build a green home. When you attend the NAHB National Green Building Conference, work toward your Certified Green Professional™ educational designation or plan the green features in your next project using the online scoring tool at nahbgreen.org, you're part of the program.

You can score your home using the NAHB Model Green Home Building Guidelines, the first national rating system for green, single-family homes.

Available at nahbgreen.org:

- online scoring tool
- explanation of the point system
- information on how to score your project to the Bronze, Silver or Gold level
- list of accredited verifiers

This score sheet will introduce you to the rating system.

Open it up and get started!

NAHB NATIONAL
GREEN BUILDING
PROGRAM™

Section		Bronze	Silver	Gold
1	Lot Design, Preparation, and Development	8	10	12
2	Resource Efficiency	44	60	77
3	Energy Efficiency	37	62	100
4	Water Efficiency	6	13	19
5	Indoor Environmental Quality	32	54	72
6	Operation, Maintenance, and Homeowner Education	7	7	9
7	Global Impact	3	5	6
	Additional points from sections of your choice	100	100	100
	TOTALS	237	311	395

Section 1: Lot Design, Preparation, and Development

1.1 Select the site to minimize environmental impact

	Your Score	Available Points	
1.1.1	___	7	Avoid environmentally sensitive areas identified through site footprinting process
1.1.2	___	9	Choose an infill site
1.1.3	___	7	Choose a greyfield site
1.1.4	___	7	Choose an EPA-recognized brownfield site

1.2 Identify goals with your team

	Your Score	Available Points	
1.2.1	___	6	Establish a knowledgeable team by identifying team member roles and writing a mission statement that includes project goals and objectives

1.3 Design the site to minimize environmental impact and protect, restore, and enhance the natural features and environmental qualities of the site

	Your Score	Available Points	
1.3.1	___	6	Conserve natural resources
1.3.2	___	6	Site the home and other built features to optimize solar resource
1.3.3	___	5	Minimize slope disturbance
1.3.4	___	6	Minimize soil disturbance and erosion
1.3.5	___	8	Manage storm water using low impact development
1.3.6	___	8	Devise landscape plans to limit water and energy demand
1.3.7	___	5	Maintain wildlife habitat

1.4 Develop the site to minimize environmental intrusion during onsite construction

	Your Score	Available Points	
1.4.1	___	5	Provide onsite supervision and coordination during clearing, grading, trenching, paving, to ensure targeted green development practices are implemented
1.4.2	___	5	Conserve existing onsite vegetation
1.4.3	___	5	Minimize onsite soil disturbance and erosion

1.5 Innovative Options

	Your Score	Available Points	
1.5.1	___	6	Share driveways or parking

Section Total _________

Section 2: Resource Efficiency

2.1 Reduce the quantity of materials used and waste generated

	Your Score	Available Points	
2.1.1	___	3	Create an efficient floor plan that maintain home's functionality
2.1.2	___	8	Employ advanced framing techniques
2.1.3	___	6	Use building layouts that maximize resources and minimize material cuts
2.1.4	___	7	Create a detailed framing plan and material takeoffs
2.1.5	___	4	Use materials requiring no additional finish resources to complete application onsite
2.1.6			Use pre-cut or pre-assembled building systems or methods as outlined below:
	___	3/per	Provide pre-cut joist or pre-manufactured floor truss
	___	6	Provide panelized wall framing system
	___	6	Provide panelized roof framing system
	___	7	Provide modular construction for entire house
2.1.7	___	4	Use a frost-protected shallow foundation

2.2 Enhance durability and reduce maintenance

	Your Score	Available Points	
2.2.1	___	6	Provide covered entry (awning, covered porch) at exterior doors
2.2.2	___	7	Use recommended-sized roof overhangs for the climate
2.2.3	___	7	Install perimeter drain for all basement footings sloped to discharge to daylight, sump pit
2.2.4	___	6	Install drip edge at eave and gable roof edges
2.2.5	___	6	Install gutter and downspout system to divert water 5 feet away from foundation
2.2.6		7	Divert surface water from all sides of building
2.2.7	___	7	Install continuous and physical foundation termite barrier where Necessary
2.2.8	___	7	Use termite-resistant materials for walls, floor joists, trusses, exterior decks, etc.
2.2.9	___	8	Provide a water-resistant barrier behind the exterior veneer or siding
2.2.10	___	5	Install ice flashing at roof edge
2.2.11	___	7	Install enhanced foundation waterproofing
2.2.12	___	9	Employ and show on plans all flashing details

2.3 Reuse materials

	Your Score	Available Points	
2.3.1	___	6	Disassemble existing buildings instead of demolishing
2.3.2	___	5	Reuse salvaged materials
2.3.3	___	6	Provide onsite bins or space to sort, store scrap materials

2.4 Recycled content materials

	Your Score	Available Points	
2.4.1	___	3	Use recycled-content building materials. List components used

2.5 Recycle waste materials during construction

	Your Score	Available Points	
2.5.1	___	7	Develop and implement a construction and demolition waste management plan
2.5.2	___	5	Conduct onsite recycling efforts
2.5.3	___	6	Recycle construction waste offsite

2.6 Use renewable materials

	Your Score	Available Points	
2.6.1	___	3-5	Use materials manufactured from renewable resources
2.6.2	___	4/per	Use certified wood and use wood-based materials from certified sources

2.7 Use resource-efficient materials

	Your Score	Available Points	
2.7.1	___	3	Use products that are composed of fewer resources

2.8 Innovative Options

	Your Score	Available Points	
2.8.1	___	5	Use locally available, indigenous materials
2.8.2	___	8	Employ a life-cycle assessment tool to choose environmentally preferable products

Section Total _________

Section 3: Energy Efficiency

3.1 Minimum Energy Efficiency Requirements

	Your Score	Available Points	
3.1.1	Mandatory		Home is equivalent to the IECC 2003 or local energy code, whichever is more stringent
3.1.2	Mandatory		Size space heating and cooling system and equipment according to building heating and cooling loads calculated using ANSI/ACCA Manual J 8th edition or equivalent
3.1.3	Mandatory		Conduct third party plan review to verify design/compliance with Energy Efficiency section

3.2 Performance Path

	Your Score	Available Points	
3.2.1	Home is X% above IECC 2003		
	___	37	15% (Bronze)
	___	62	30% (Silver)
	___	100	40% (Gold)

3.3 Prescriptive Path

An energy-efficiency practice identified with a "(PP)" in Section 3.3 is a Performance Path practice likely to be used to calculate X% above ICC IECC in Section 3.2. If Section 3.3 is used to obtain points in addition to points from 3.2, those practices from Section 3.3 used to comply with Section 3.2 shall not be awarded any additional points.

3.3.1 Building Envelope

Increase effective R-value of building envelope using advanced framing techniques, continuous insulation, and/or integrated structural insulating system. Measures may include but are not limited to:

	Your Score	Available Points	
A.(PP)	___	8	SIP, or
	___	8	ICF, or
	___	6	Advanced framing or insulated corners, intersections and headers
	___	2	Raised heel trusses
	___	4	Continuous insulation on exterior wall
	___	4	Continuous insulation on cathedral ceiling
B.(PP)	___	5	10 Air sealing package is implemented to reduce infiltration
C.(PP)	___	5	ENERGY STAR®-rated windows appropriate for local climate

3.3.2 HVAC design, equipment, and installation

	Your Score	Available Points	
A.	___	8	Size, design, and install duct system using ANSI/ACCA Manual D® or equivalent
B.	___	8	Design radiant/hydronic space heating systems using industry approved guidelines
C.	___	8	Use ANSI/ACCA Manual S® or equivalent to select heating and cooling equipment
D.	___	8	Verify performance of the heating and cooling system
E.	___	6	Use HVAC installer or technician certified by national or regionally recognized program
F.(PP)	Fuel-fired space heating equipment efficiency (AFUE)		
	___	4	Gas furnace > 81%
	___	6	Gas furnace > 88% (ENERGY STAR)
	___	8	Gas furnace > 94%
	___	2	Oil furnace > 83%
	___	2	Gas or oil boiler > 85% (ENERGYSTAR)
	___	6	Gas or oil boiler > 90%
G.(PP)	Heat pump efficiency (cooling mode)		
	___	6	SEER 13-14
	___	6	SEER 15-18
	___	7	SEER 19+
	___	9	Staged air conditioning equipment
H.(PP)	Heat pump efficiency (heating mode)		
	___	6	7.2 - 7.9 HSPF
	___	7	8.0 - 8.9 HSPF
	___	9	9.0 - 10.5 HSPF
	___	10	> 10.5 HSPF

Note: *Split systems must be ARI-tested as a matched set*

	Your Score	Available Points	
I.(PP)	Ground source heat pump installed by a certified geothermal service contractor (cooling mode)		
	___	5	EER = 13-14
	___	6	EER = 15-18
	___	8	EER = 19-24
	___	10	EER = >25

Note: *For Sections A-F and I, add 3 points if Manuals S and D and start-up procedures are followed when units are installed*

	Your Score	Available Points	
J.(PP)	Ground source heat pump installed by a certified geothermal service contractor (heating mode)		
	___	6	COP 2.4 - 2.6
	___	8	COP 2.7 - 2.9
	___	10	COP > 3.0
K.	___	6	Seal ducts, plenums, equipment to reduce leakage. Use UL 181 foil tapes and/or mastic
L.	___	8	When installing ductwork: 1. Do not use building cavities used as ductwork, e.g., panning joist or stud cavities 2. Install all heating and cooling ducts and mechanical equipment within conditioned envelope 3. Do not install ductwork in exterior walls
M.	___	6	Install return ducts/transfer grilles in rooms with doors (except baths, kitchen, closets, laundry)
N.	___	1/per	Install ENERGY STAR-rated ceiling fans
O.	___	4	Install whole-house fan with insulated louvers
P.	___	8	Install ENERGY STAR-labeled mechanical exhaust for every bathroom ducted to outside

3.3.3 Water heating design, equipment, and installation

	Your Score	Available Points	
A.	___	4	Water heater Energy Factor equal to or greater than those listed

Natural Gas:

Size (gallons)	Energy Factor
30	0.64
40	0.62
50	0.60
65	0.58
75	0.56

Electric:

Size (gallons)	Energy Factor
30	0.95
40	0.94
50	0.92
65	0.90
80	0.88
100	0.86

Oil:

Size (gallons)	Energy Factor
30	0.59
50	0.55

	Your Score	Available Points	
B.	___	4	Install whole house instantaneous (tankless) water heater
C.	___	4	Insulate all hot water lines with a minimum of 1" insulation
D.	___	3	Install heat trap on cold and hot water lines to and from the water heater
E.	___	5	Install manifold plumbing system (parallel piping configuration, stacking plumbing)

3.3.4 Lighting and appliances

	Your Score	Available Points	
A.	___	7	Use an ENERGY STAR Advanced Lighting Package
B.	___	7	Install all recessed fixtures within the conditioned envelope
C.	___	7	Install motion sensors on outdoor lighting
D.	___	2	Install tubular skylights in rooms without windows
E.	Install ENERGY STAR-labeled appliance:		
	___	3	Refrigerator
	___	3	Dishwasher
	___	5	Washing machine

3.3.5 Renewable energy/solar heating & cooling

3.3.5.1 Solar space heating & cooling (see Guidelines for details)

	Your Score	Available Points	
A.	___	10	Use sun-tempered design: building orientation, sizing of glazing, design of overhangs to provide shading
B.	___	10	Use passive solar design: sun-tempered design as above plus additional southfacing glazing, appropriately designed thermal mass to prevent overheating
C.	___	8	Use passive cooling, including shading, overhangs, window cross ventilation

3.3.5.2 Solar water heating

	Your Score	Available Points	
A.	Install SRCC-rated solar water heating system		
	___	8	Solar fraction: 0.3
	___	10	Solar fraction: greater than or equal to 0.5

3.3.5.3 Additional renewable energy options

	Your Score	Available Points	
A.	Supply electricity needs by onsite renewable energy source whereby the system is estimated to produce the following kWh per year:		
	___	8	2,000 – 3,999 kWh per year
	___	10	4,000 – 5,999 kWh per year
	___	12	Greater than or equal to 6,000 kWh per year
B.	Provide clear and unshaded roof area (+/- 30 degrees of south or flat, minimum 200 square feet) for future solar collector or photovoltaics. Provide rough-in piping from the roof to the utility area.		
	___	3	Conduit
	___	5	Insulated piping
C.	___	2	Provide homeowners with information and enrollment materials about options to purchase green power from the local electric utility.

3.3.6 Verification

	Your Score	Available Points	
3.3.6.1	___	8	Conduct onsite third-party inspection to verify installation of energy-related features
3.3.6.2	___	8/per	Conduct third-party testing to verify performance: blower door, duct leakage, flow rates

3.3.7 Innovative Options

	Your Score	Available Points	
A.	___	2	Install drainwater heat-recovery system
B.	___	6	Install de-superheater in conjunction with ground-source heat pump
C.	___	6	Install heat pump water heater rated to current DOE test standard and with EF > 1.7

Section Total ________

Section 4:Water Efficiency

4.1 Water Use

	Your Score	Available Points	
4.1.1	___	6/per	Hot water delivery to remote locations aided by installation of: A. On-demand water heater at point of use served by cold water only B. Control-activated recirculation system
4.1.2	___	9	Water heater located within 30 feet pipe run of all bathrooms and kitchen
4.1.3	___	7/per	ENERGY STAR water-conserving dishwasher, washing machine, etc.
4.1.4	___	2/per	Water-efficient showerhead using aerator/venturi with flow rate < 2.5 gpm
4.1.5	___	2/per	Water-efficient sink faucets/aerators < 2.2 gpm
4.1.6	___	4-6	Ultra low flow (< 1.6 gpm/flush) toilets: (power-assist: 4 pts; dual flush: 6 pts)
4.1.7	___	7	Low-volume, non-spray irrigation system installed such as drip irrigation, bubblers, etc.
4.1.8	___	6	Irrigation system zoned separately for turf and bedding areas
4.1.9	___	7	Weather-based irrigation controllers such as computer-based weather record
4.1.10	___	9	Collect and use rainwater, as permitted by local code
4.1.11	___	7	Innovative wastewater technology as permitted by local code

4.2 Innovative Options

	Your Score	Available Points	
4.2.1	___	6	Shut-off valve, motion sensor, or pedal-activated faucet for intermittent on/off operation
4.2.2	___	6	Separate and re-use greywater as permitted by local code
4.1.3	___	6	Composting or waterless toilet as permitted by local code

Section Total ________

Section 5: Indoor Environmental Quality

5.1 Minimize potential sources of pollutants

	Your Score	Available Points	
5.1.1	___	**8**	For vented space heating and water heating equipment: A. Install direct vent equipment B. Install induced/mechanical draft combustion equipment
5.1.2	___	6	Install space heating and water heating equipment in isolated mechanical room or closet with an outdoor source of combustion and ventilation air
5.1.3	___	6	Install direct-vent, sealed-combustion gas fireplace, sealed wood fireplace, or sealed woodstove or install no fireplace or woodstove
5.1.4	___	9	Ensure a tightly-sealed door between the garage and living area and provide continuous air barrier between garage and living areas including air sealing penetrations
5.1.5	___	6	Ensure particleboard, medium density fiberboard (MDF) and hardwood plywood substrates are certified to low formaldehyde emission standards
5.1.6	___	6	Install carpet, carpet pad, and floor covering adhesives that hold "Green Label" from Carpet and Rug Institute's indoor air quality testing program or equivalent
5.1.7	___	5	Mask HVAC outlets during construction and vacuum all ducts, boots, and grills
5.1.8	___	3	Use low-VOC emitting wallpaper

5.2 Manage potential pollutants generated in the home

	Your Score	Available Points	
5.2.1	___	7	Vent kitchen range exhaust to the outside
5.2.2			Provide mechanical ventilation at a rate of 7.5 cfm per bedroom + 7.5 cfm and controlled automatically or continuous with manual override. Choose:
	___	7	Exhaust or supply fan(s)
	___	9	Balanced exhaust and supply fans
	___	10	Heat-recovery ventilator
	___	10	Energy-recovery ventilator
5.2.3	___	3	Install MERV 9 filters on central air or ventilation systems
5.2.4	___	4	Install humidistat to control whole-house humidification system
5.2.5	___	6	Install sub-slab depressurization system to facilitate future radon mitigation system
5.2.6	___	9	Verify all exhaust flows meet design specifications

5.3 Manage moisture (vapor, rainwater, plumbing, HVAC)

	Your Score	Available Points	
5.3.1	___	6	Control bathroom exhaust fan with a timer or humidistat
5.3.2	___	6	Install moisture-resistant backerboard under tiled surfaces in wet areas
5.3.3	___	9	Install vapor retarder directly under slab (6-mil) or on crawl space floor (8-mil)
5.3.4	___	6	Protect unused moisture-sensitive materials by just-in-time delivery, storing in dry area, or tenting and storing on raised platform
5.3.5	___	5	Keep plumbing supply lines out of exterior walls
5.3.6	___	4	Insulate cold water pipes in unconditioned spaces
5.3.7	___	4	Insulate HVAC ducts, plenums, and trunks in unconditioned basements and crawl spaces
5.3.8	___	4	Check moisture content of wood before it is enclosed on both sides

Section Total ________

Section 6: Operation, Maintenance, and Homeowner Education

	Your Score	Available Points	
6.1	___	**9**	Provide Home Manual to owners/occupants on the use and care of the home. (*See Guidelines for details.*)
6.2	___	2	Include optional information in the Home Manual. (*See Guidelines for details.*)
6.3	___	7	Provide education to owners/occupants in the use and care of their dwellings: Instruct homeowner/occupants about the building's goals and strategies and occupant's impact on costs of operating the building. Provide training to owners/occupants for all control systems in the house.
6.4	___	1	Solid waste: Encourage homeowners/occupants to recycle by providing built-in space in the home's design (kitchen, garage, covered outdoor space) for recycling containers

Section Total ________

Section 7: Global Impact

7.1 Products

	Your Score	Available Points	
7.1.1	___	**3**	Note product manufacturer's operations and practices (environmental management system)
7.1.2	___	6	Choose low- or no-VOC indoor paints
7.1.3	___	5	Use low-VOC sealants

7.2 Innovative options

	Your Score	Available Points	
7.2.1	___	**4**	Demonstrate that builder's operations and business practices include environmental management system concepts

Section Total ________

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